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ANOMALIES OF SEA SURFACE TEMPERATURES AND CURRENTS IN THE JACKS--ETC(U)

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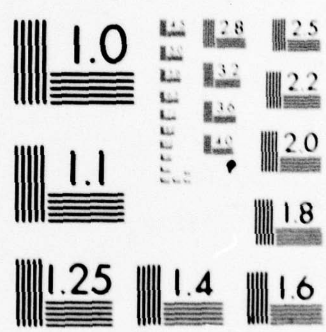

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14 NWRF-TECHNICAL PAPER No. 12-66

6 ANOMALIES OF SEA SURFACE TEMPERATURES AND CURRENTS IN THE JACKSONVILLE, FLORIDA FLEET OPERATING AREA

by

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ABSTRACT

1. INTRODUCTION

The Jacksonville Fleet Operating Area, and the coastal sections of Georgia and northern Florida are areas that have periods of fog and low status that are difficult to forecast. A major factor in the formation of this fog and low stratus is the ocean which provides the required moisture and variable temperature conditions. This paper presents a mesoscale climatological study of the sea surface temperatures (SST) for the area. Several case studies have been provided to relate actual patterns to the climatic charts and to illustrate that SST charts can be prepared on a daily basis. A more accurate knowledge of the sea surface temperature conditions, operationally and climatologically should greatly improve fog and low stratus forecasting capability. This study is of the Jacksonville Fleet Operating Area, but the principles could be applied to any area of the world where the ocean provides temperature variations sufficient to cause fog or low stratus conditions. ABSTRACT

The term Gulf Stream refers to a current system that extends from the Gulf of Mexico to the coasts of Scandanavia and western Europe. Sections of this current system have distinct characteristics and each section has been given a name. Unfortunately, all authors have not agreed upon the same name for the same section of this current system. In this paper the various sections of the current system are described and named to assure proper identification. To avoid ambiguity, the section of the current over the Blake Plateau has been named the Plateau Current.

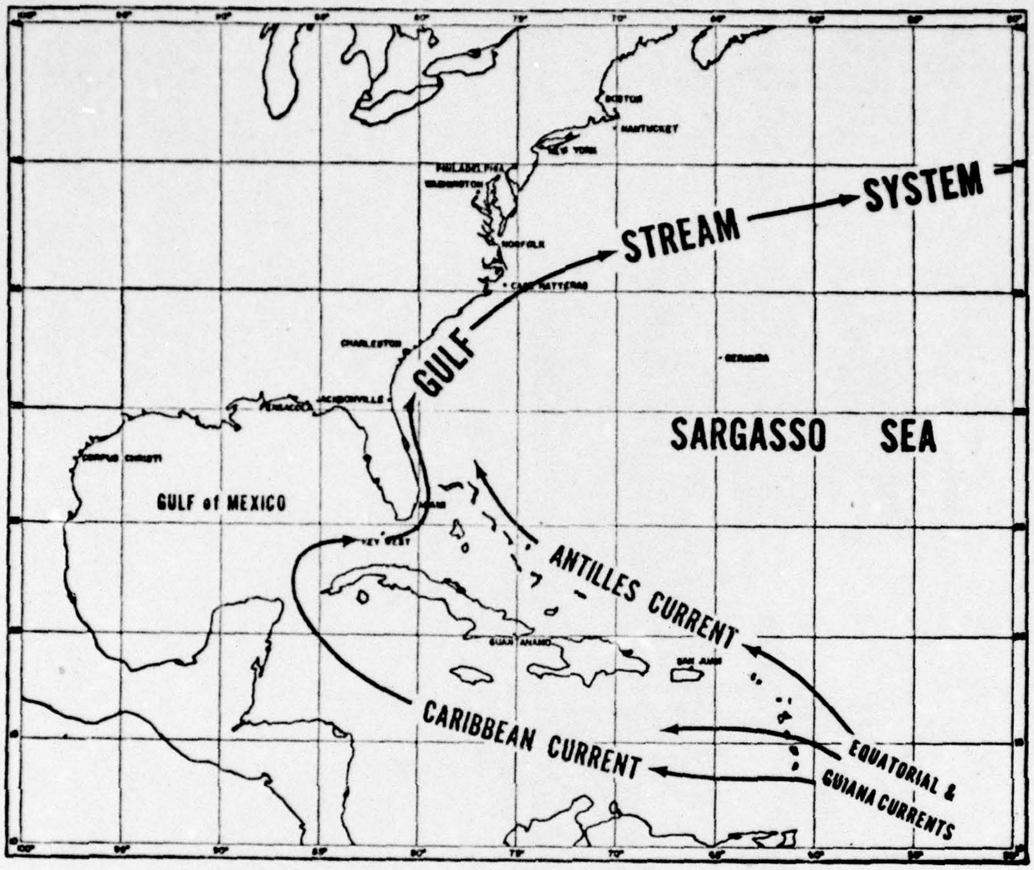


Figure 1. Currents of the Gulf Stream System.

2. THE GULF STREAM SYSTEM

The surface currents that eventually merge to make the Gulf Stream system start in the Equatorial Atlantic Ocean. The South Equatorial Current flows to the west until it reaches the coast of South America at the eastern tip of Brazil where it splits into a southern and northern branch. The northern branch, the Guiana Current, joins the North Equatorial Current as the enter the Caribbean Sea between the Lesser Antilles island chain. These combined currents become the Caribbean Current as they flow westward from the Lesser Antilles. The current on the Atlantic side, but adjacent to the islands, becomes the Antilles Current.

At the western end of the Caribbean Sea, the current becomes the Yucatan Current as it passes through the Yucatan Channel (approximately 1600 meters deep). A minor amount of this water flows clockwise around the Gulf of Mexico producing a weak and variable current, but the major portion of the current turns eastward into the Straits of Florida (approximately 800 meters deep).

According to Montgomery (1938), the persistant easterly tradewinds in the Caribbean Sea causes the water to pile up in the Gulf of Mexico so that the average sea level at Cedar Keys, on the west coast of Florida, is 19 centimeters higher than at St. Augustine on the east coast of Florida. He shows that this hydrostatic head accounts for a major part of the energy in this section of the Gulf Stream system which passes through the Straits of Florida.

In a major current the water mass distribution is such that the lighter water is found on the right hand side of the current and the sea surface rises to the right when looking in the direction of the flow. This effect is increased in swift, narrow currents. Montgomery computed that the sea level is 45 centimeters higher along the coast of Cuba than it is at Key West, Florida.

Iselin (1933 and 1936) suggested dividing the Gulf Stream system into three parts for scientific reference. He defined the section from the Tortugas, through the Straits of Florida, to a point where the current separates from the continental slope (southeast of Cape Hatteras) as the Florida Current.

From there to the Flemish Cap, a small bank east of the Grand Bank, the current was called the Gulf Stream. East of the Flemish Cap, it was called the North Atlantic Current.

Sverdrup et al (1942) use these definitions, but both von Arx (1962) and Stommel (1965) restrict the name "Florida Current" to the Straits of Florida. They call the current from the Straits of Florida to the Flemish Cap the Gulf Stream.

The Gulf Stream system can be easily divided into sections based on the distinctive features of the current as well as geographical location. The current in the Straits of Florida is physically restricted to a channel by Florida, Cuba and the Bahama Islands. At this point it flows at the rate of 26 million m^3/sec. (6 million m^3/sec. from the South Atlantic via the Guiana Current). There seems to be no disagreement that this should be called the Florida Current. There also seems to be no disagreement about calling the current from Cape Hatteras eastward to the Flemish Cap, the Gulf Stream; or the current to the east of the Flemish Cap, the North Atlantic Current. The Gulf Stream, as defined in this paragraph, has no physical restrictions from either the sides or the bottom of the current. Fuglister (1960), based upon oceanographic observations that he made north and south along 68° 30' W. longitude, computed the volume transport to be 137 million m^3/sec if the measurements are considered all the way to the bottom (5300 meters). Assuming no motion below 2000 meters (which is an oceanographic convention) the volume transport drops to 89 million m^3/sec.

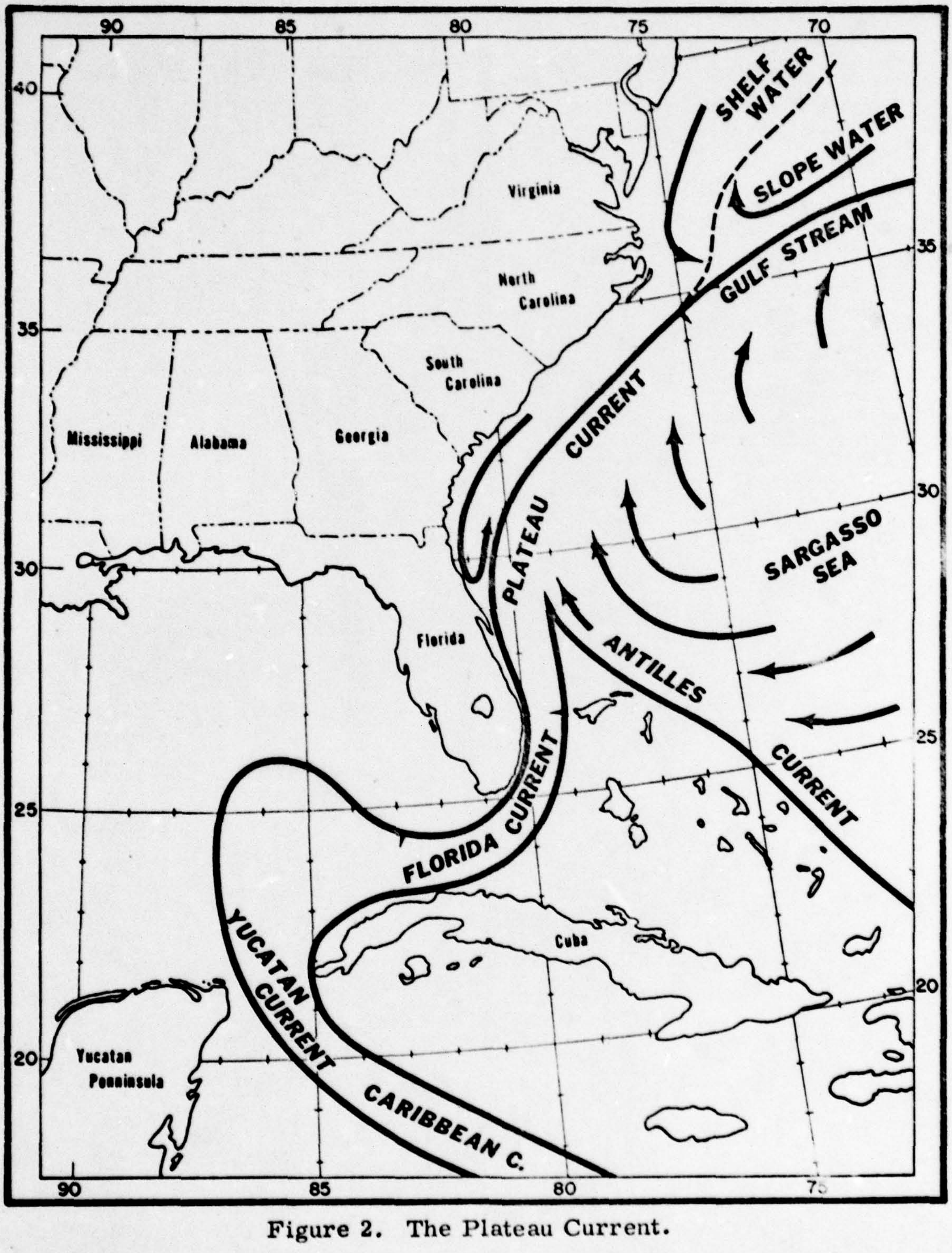


Figure 2. The Plateau Current.

In the section between the Florida Current and the Gulf Stream (as defined here) there is a current that is distinctly different from the others. It is physically restricted by the continental shelf on the left, which forces a change of direction of almost 60°. It is joined by another current, the Antilles Current, which contributes an estimated 12 million m^3/sec. to its volume transport. It forms a dynamic barrier to the lighter water of the Sargasso Sea and prevents it from spreading over the slope and shelf water. Its volume transport more than triples from the Straits of Florida to the point where it leaves the continental shelf southeast of Cape Hatteras. It is known that this current extends all the way to the bottom, the Blake Plateau at 800 meters. Therefore, it is convenient to designate this portion of the current system the Blake Plateau Current, or simply the Plateau Current.

3. SEA SURFACE TEMPERATURE CHARTS

3.1 The Problem

There are probably more books and papers written about the Gulf Stream system than any other current system in the world; however, most of these studies and detailed observations have been concentrated in three regions: east of Cape Hatteras, the vicinity of the Carolina Bays and the Straits of Florida. The present mesoscale study is of a relatively small section of the Plateau Current and the inshore countercurrents in the area between 28° 30' N. and 32° 12' N. latitude, and 79° W. longitude and the coastline. There are at least three papers which do mention this area. They are the reports by Iselin (1936), von Arx, Bumpus and Richardson (1955), and Webster (1964). These are used for background information. Standard climatic charts of sea surface temperature (SST) are based on data grids of from 1 to 5 degrees of latitude and longitude. They tend to imply that there are only one or two isotherms in the study area and that the current system is static. This paper shows that the current system fluctuates over wide limits on a monthly and daily basis, and presents operational methods of tracking SST features.

3.2 Data

The National Weather Records Center, Asheville, N. C. supplied 1,333,785 ship weather observations taken in the Jacksonville Fleet Operating Area during the period from January 1949 through December 1962, and U. S. Navy ship observations during the period between January 1961 and September 1965. Several aircraft surveys were also made during 1962 and 1963. Un-

fortunately, most of the data from commercial shipping is concentrated in the Plateau Current (see figure 3). Ships traveling north use the current to augment their speed (3-6 knots). Ships traveling south either are fast enough so that it is economical to accept the loss of speed by bucking the current and travel the shortest distance, or they travel inshore from the strongest current. The areas with a density of 20 or more observations outside the main current are where ships going to, or coming from, the main current cross the inshore traffic lanes. The Navy ships tend to avoid the area of commercial ship concentrations, (figure 3), so their observations help to fill in the thinner data areas.

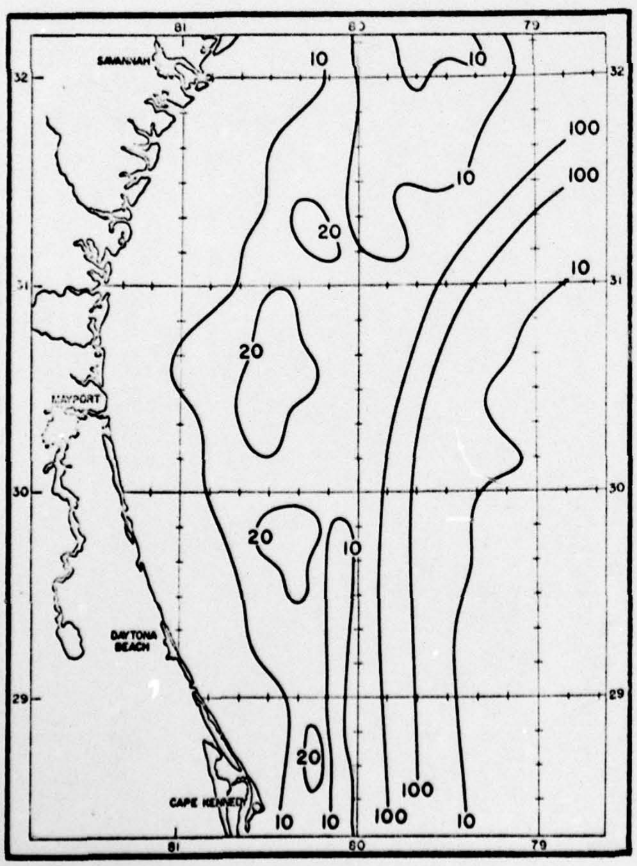


Figure 3. Typical Data Density, Number of Observations in each Grid Area per Month.

During the aircraft observations while checking the littoral or coastal current areas a large spring was found at 30° 02' N., 81° 16' W. (about 9 miles NNE of St. Augustine, Florida). Except for a short period in August 1962 when the plume became diffuse and meandering between east and southeast, the surface current flow, as indicated by this plume of muddy water, is from a northerly direction parallel to the beach.

Data from coastal tide stations is from the Coast and Geodetic Survey, ESSA, (1965). With the exception of Daytona Beach, Florida, these tide stations are on rivers and bays. This will bias the data towards the landmass temperatures. During the winter and spring the northern rivers would have run-off water that would be colder than the ocean temperatures. In the summer and autumn all the rivers are likely to be warmer than the ocean. Some estimate of this influence can be made from the salinities at the various tide stations (Table 1).

3.3 Data Grid Size

One purpose of this study is to magnify the detail of the SST structure in the ocean area east of Jacksonville and at the same time maintain acceptable accuracy. Climatic charts normally use a data grid of from 1 to 5 degrees on longitude and latitude. Averaging small scale features over this large a grid results in 1, at the most 2, meaningless isotherms. Pyle (1962) prepared an atlas using a grid of 0.5 degrees (30- minutes of latitude, figure 4). This is certainly an improvement over the larger grids, but when this same data is expanded to Jacksonville Fleet Operating Area chart, the

small scale features that appear on figure 4 appear to have been smoothed, see figure 5.

Table 1. Salinities $^{o}/_{oo}$

TIDE STATION	Low Monthly Mean	High Monthly Mean	Annual Mean
Fort Pulaski, Savannah River, Ga.	12.0	19.9	16.9
Fernandina Beach, Florida[1]	27.5	31.9	29.8
Mayport, Florida[2]	20.0	29.3	24.0
Jacksonville, Fla.[3]	6.1	13.9	9.2
Daytona Beach (ocean), Fla.	34.1	36.2	35.2
Patrick AFB (ocean), Fla.	34.8	36.7	35.9
Miami Beach (ocean)	35.4	36.4	35.8

[1] Located in a small bay near the mouth of the St. Marys River.
[2] About 1 mile from the mouth of the St. Johns River.
[3] About 18 miles from the mouth of the St. Johns River.

Ford and Miller (1952) defined the several water types associated with the Gulf Stream system at 37° N. latitude:

Shelf Water	33 $^{o}/_{oo}$
Slope Water	35 $^{o}/_{oo}$
Gulf Water	36 $^{o}/_{oo}$
Sargasso Sea Water	36 $^{o}/_{oo}$

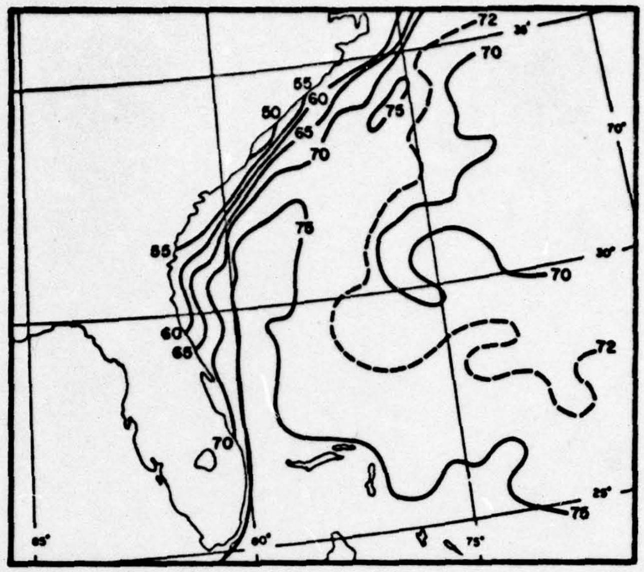


Figure 4. January, 30 Minute Data Grid.

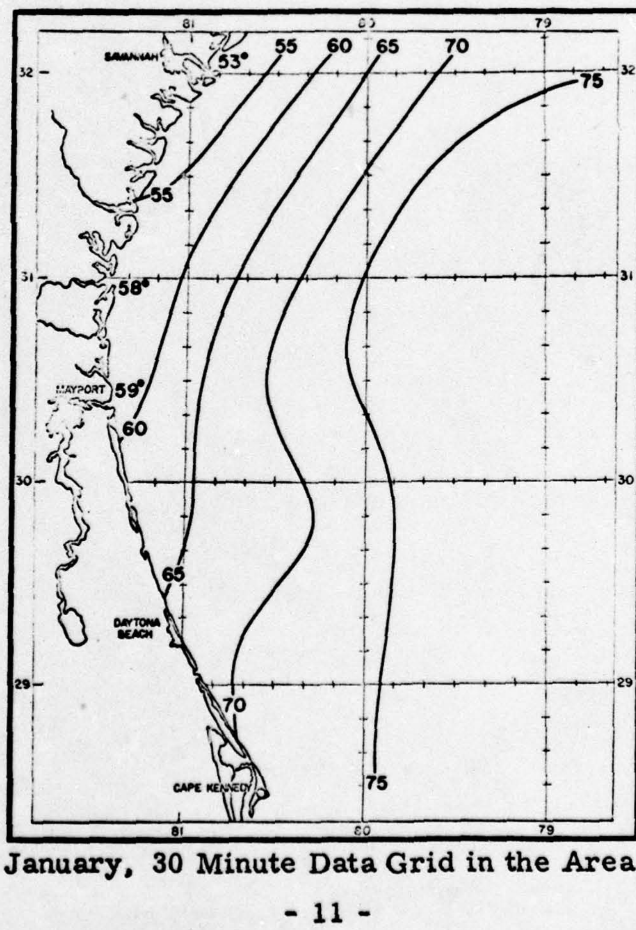


Figure 5. January, 30 Minute Data Grid in the Area of This Study.

The ship weather observation positions are recorded in 0.2 degree (12 minutes of longitude or latitude). This also appears to be the optimum grid for plotting data concerning this current system. Any increase in grid size results in a loss of characteristics, see figure 6.

Figure 6, is the data from 14 years of observations averaged in a 0.2 degree (12 minute) grid system. The data was compared vertically and horizontally for obvious errors, but smoothing of the data was kept to a minimum. Some of the features retained may be insignificant, but none of the significant data has been lost because of excessive smoothing. There is a significant increase in the detail of the SST isotherms between figures 5 and 6; however, there is an even larger increase between figure 6 and the case studies, which will be presented later.

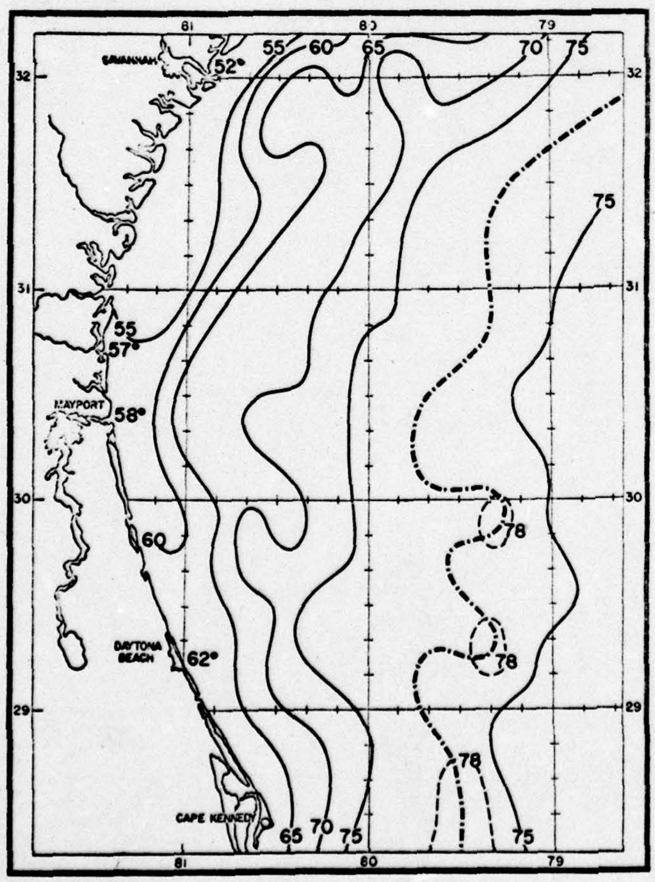


Figure 6. January, 12 Minute Data Grid.

3.4 Current Dynamics

The Gulf Stream system is not a well defined river of warm water flowing northward through the North Atlantic Ocean, but a dynamic boundary current that prevents the waters of the Sargasso Sea from spreading over the colder slope and shelf currents. The warmer lighter water is displaced to the right of a swift current. Defant (1961) has computed that there is a ridge in the sea level height along the right side of the Gulf Stream system that runs from the Bahama Islands to a point southwest of the Grand Bank. Rossby (1936) in his wake-jet theory paper states that there must be compensating countercurrents, on the left of the current and possibly on the right as well. The right edge, looking in the direction of the current flow, of the countercurrents must also be higher than the left edge. This would mean that the water level along the coast would be slightly higher than a point off-shore between the currents. Figure 7 is a simplified schematic of the current systems in the area of this study. The littoral, or coastal, current is a nearly laminar current that varies in proportion to the river runoff. It is most apparent from October through March when the river water, though colder than the ocean water, is still less dense because of salinity differences. During the rest of the year it is masked by vernal warming of the sea surface.

The Shelf Current, also from the north, is one of the least turbulent systems in the area. It is believed to persist during all months of the year and extend from the surface to the bottom (10 to 40 meters, 33 to 132 feet).

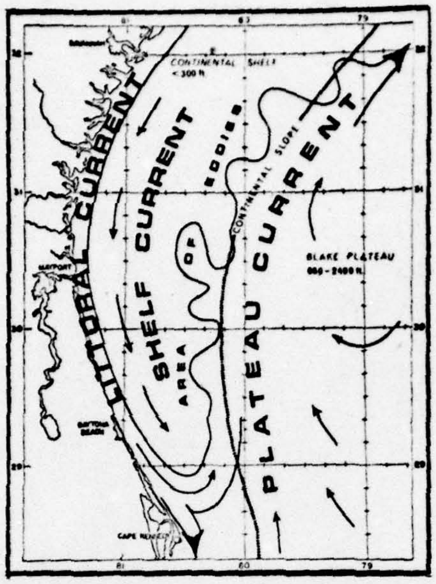


Figure 7. Currents in the Study Area.

The Area of Eddies is the area where the most interaction between the cold Shelf Current and the warm Plateau Current occurs. The current in this area would be extremely variable, with the northern component of the eddies increasing as the western edge of the Plateau Current is approached.

The Plateau Current, flowing from the south with speeds reported as high as 6 knots, generally follows the shape of the continental slope. The Plateau Current can almost always be followed as a "stream", even in the months of July, August, and September when the other current features are masked by warming of the surface water. The current is not laminar, apparently having large scale eddies, or water masses of variable temperature at least, distributed along its length. It also seems to be in a continuous meander, although it is confined on the left by the continental slope and on the right by the dynamics of the pressure ridge mentioned earlier.

On the right of the Plateau Current the temperature and current variations are smaller. In the southeast corner of the area chart the Antilles Current can sometimes be detected, although it usually merges with the Plateau Current a little further to the south. Richards and Redfield (1955) found that the Antilles Current was quite variable. Occasionally counter-currents or cut-off eddies will be noted along the eastern edge of the Plateau Current.

Figure 8 is a very simplified cross-section of the current systems from the coast through the Plateau Current to illustrate the change in the height of the sea level. Although the Littoral Current (river run-off) is colder, it remains on top of the warmer shelf current because the water is fresher.

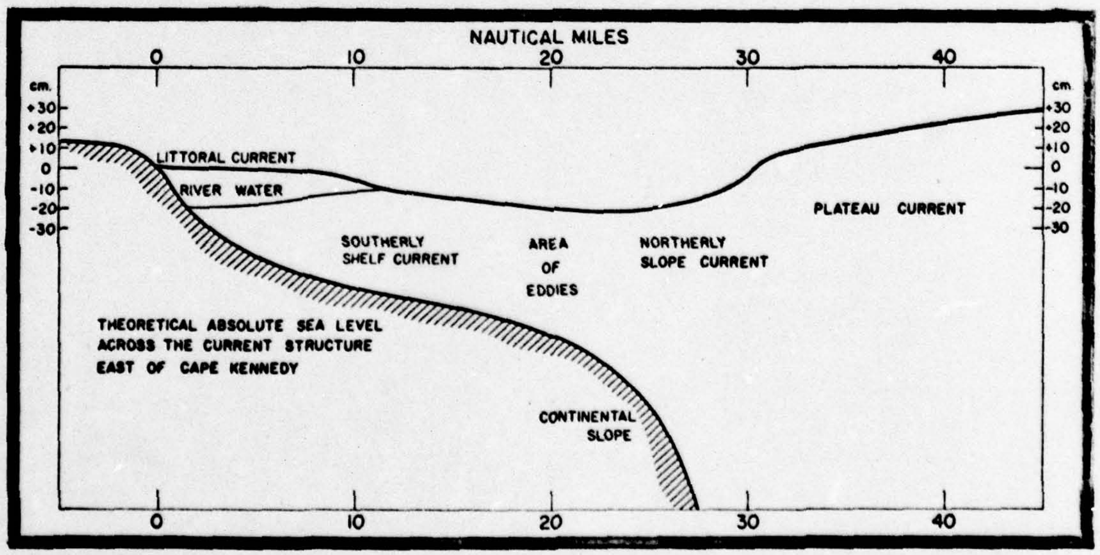


Figure 8. Cross-Section of Currents in the Study Area.

There will be an exchange of heat and water across the interface and the Littoral Current will gradually disappear by mixing, or sinking, as the water conditions approach each other in similarity.

Some of the Littoral and Shelf Current water will occasionally flow around Cape Kennedy and continue south, particularly when the Plateau Current has meandered well off-shore; however, most of this inshore water becomes a cold intrusion into the side of the Plateau Current and is carried to the north as a cold eddy. Depending upon its temperature, salinity, and the density of the sub-surface water under it, it could be lower, level with, or higher than the adjoining sea level.

3.5 Sea Surface Temperature (SST) Monthly Charts

Just as the analyses were not smoothed excessively to avoid losing any data that might prove significant, the average, maximum, and minimum SST charts are included for all months of the year. Oceanographic data density is very low compared to weather observations made over the land areas of the world. From figure 3 you will note that there are areas where the data density is less than 10 reports for a particular month over the 14-year period. There is no way to determine whether all the reports were made during the same year, or one each year, both of which are unlikely. If a preponderance of the observations for one grid square were made during a warm year the analysis would be skewed in that direction. The small grid has the advantage of making this skewness obvious, if it is large; but only adding insignificant detail if it is small. During the summer months,

most of the detail is lost because of seasonal warming of the surface layers.

Table 2. Average Temperatures Occurring in the Jacksonville Fleet Operating Area by Month

°F	°C	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
85	29.4						x	x	x				
80	26.7				x	x	x	x	x	x	x	x	
75	23.9	x	x	x	x	x					x	x	
70	21.1	x	x	x	x							x	x
65	18.3	x	x	x	x							x	x
60	15.6	x	x	x									x
55	12.8	x	x										x
50	10.0		x										

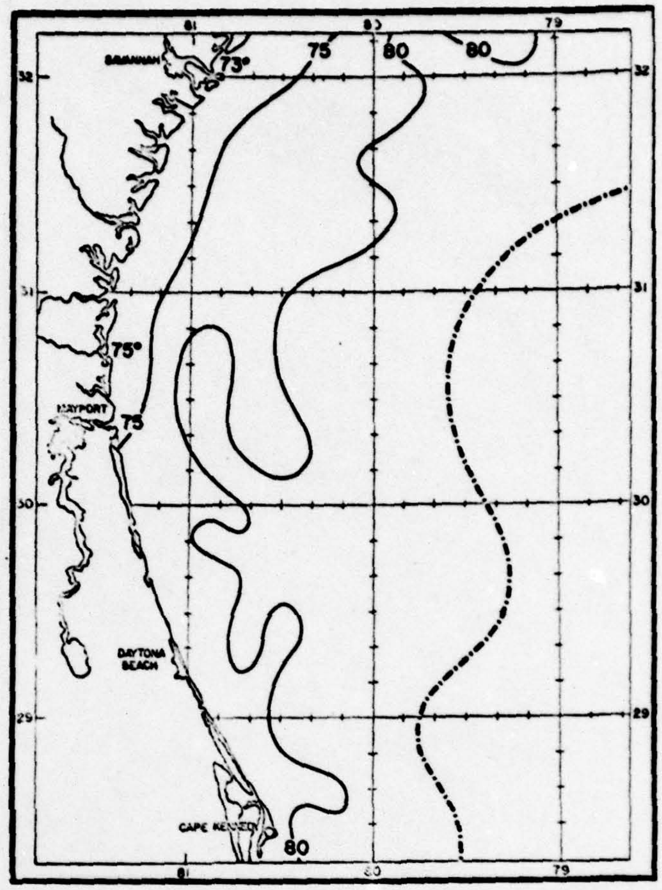
The volume transport for the Plateau Current reaches a minimum in the last part of October - first part of November with step-like increases in January and April, and finally reaching a maximum in July. For this reason October was chosen as the starting month for this series of charts.

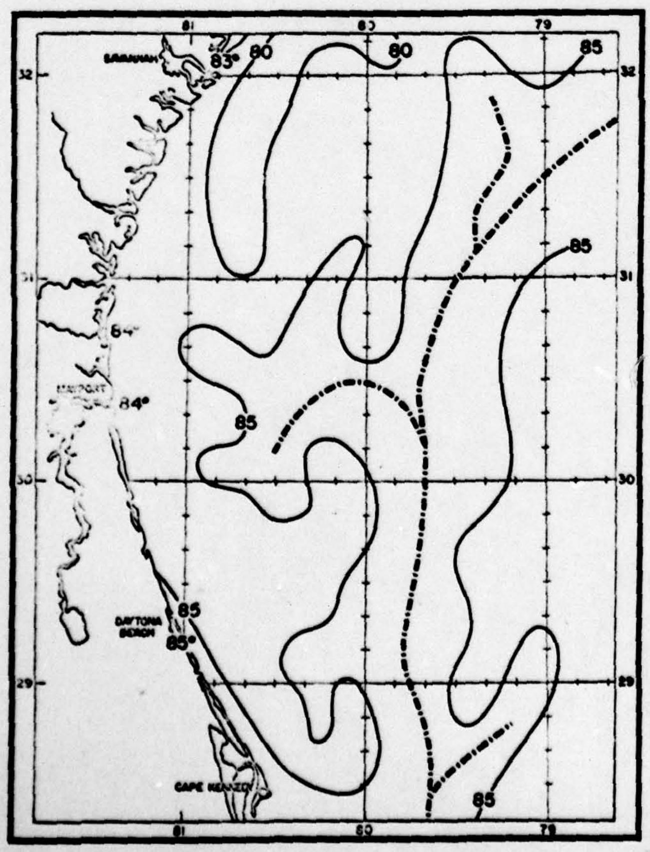
October

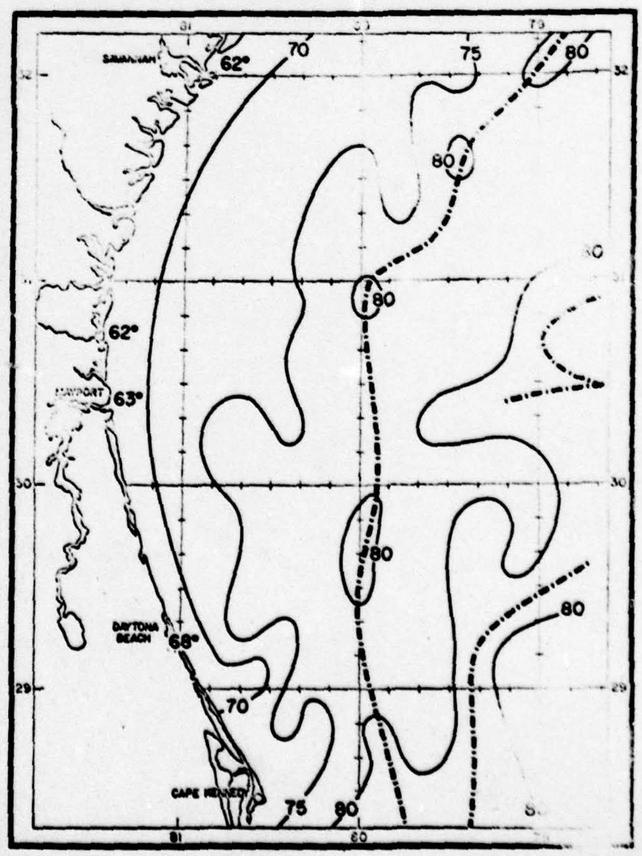
Right. Average SST
The temperature gradient has been masked by surface warming. The warm core of the current is marked with the dash-dot line.

Lower left. Maximum SST
The cool Shelf Current has separated from the beach south of Daytona Beach, Florida.

Lower right. Minimum SST
The Plateau Current appears to have two warm cores, one that recurves to the east and a spotty core that follows the edge of the continental slope. The latter would probably be a better indicator of the sub-surface structure.





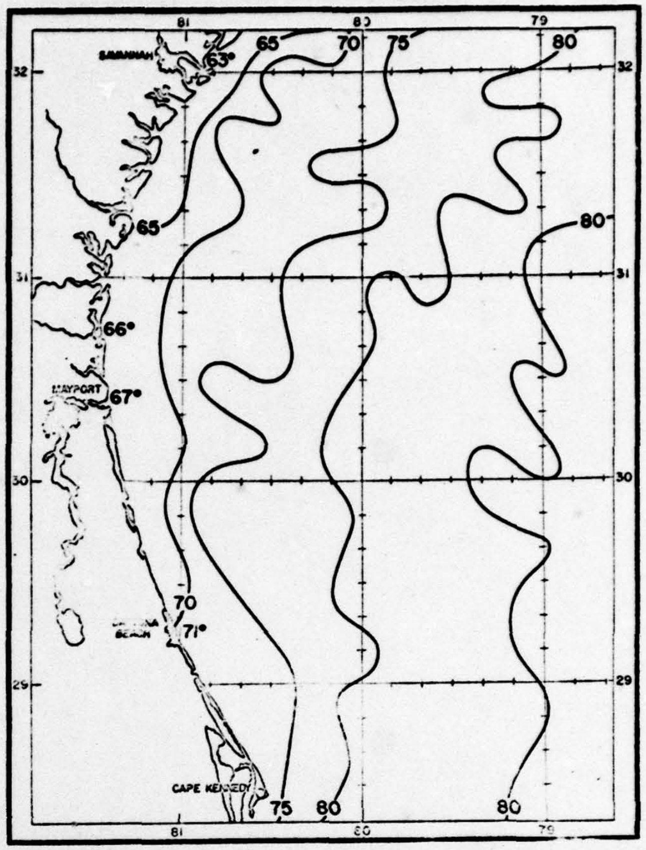


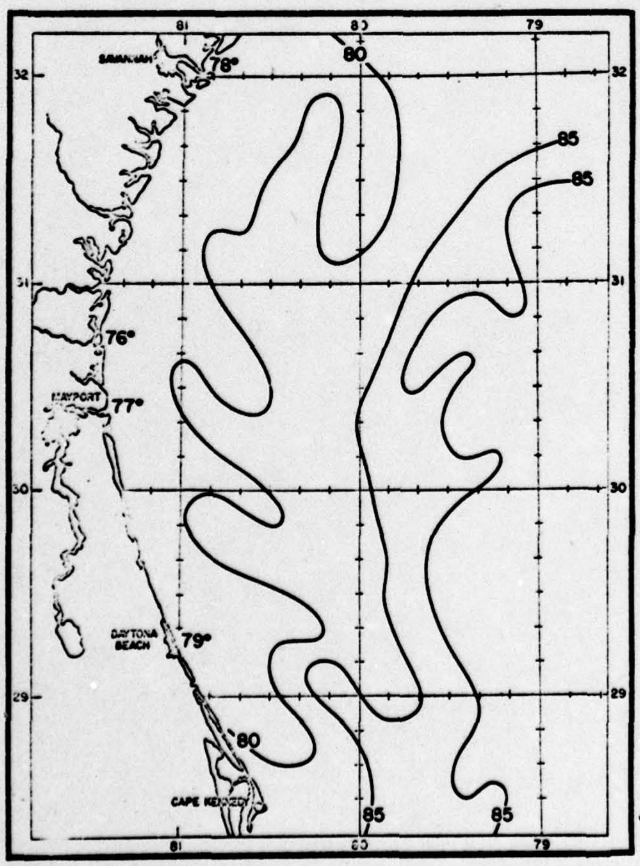
November

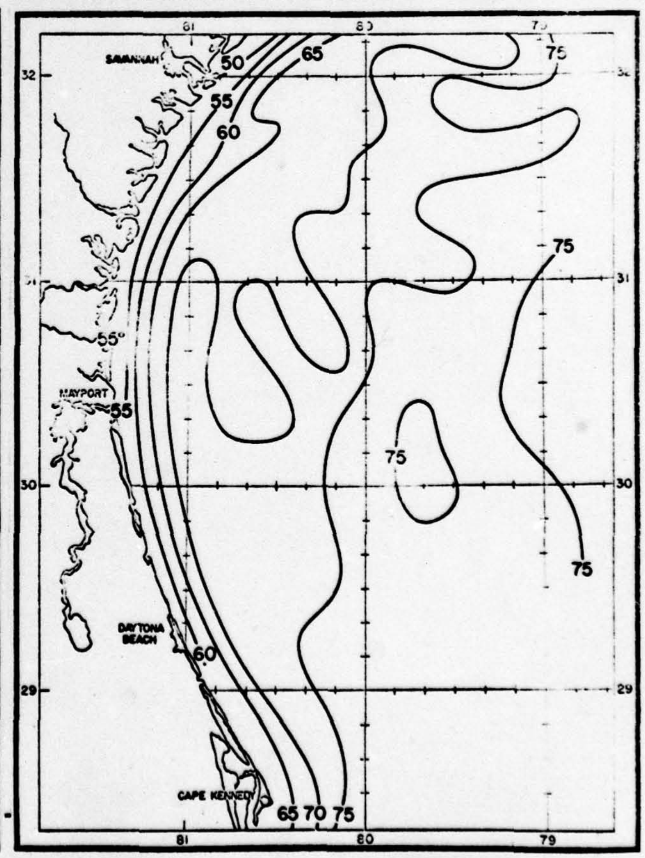
Right. Average SST
Some of the variability in these isotherms of average SST is very likely insignificant, however the preferred location for cold water intrusions is north of 30° N. in November. The intrusions from the east are indicative of the number of cold intrusions that pass through the upper layers of the Plateau Current to re-enter it as cold eddies from the east.

Lower left. Maximum SST

Lower right. Minimum SST
The colder, fresher river run-off prominently outlines the Littoral Current.





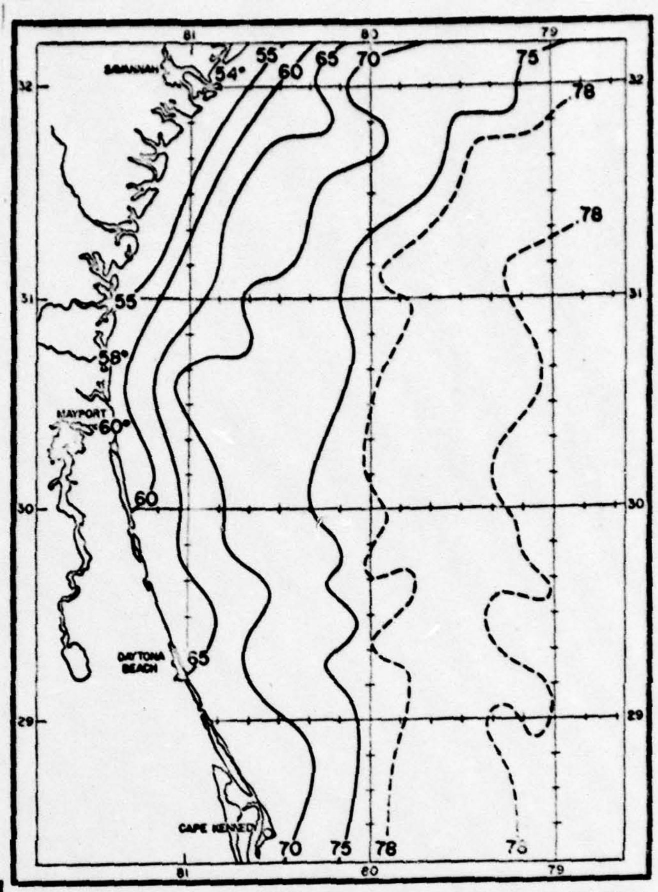


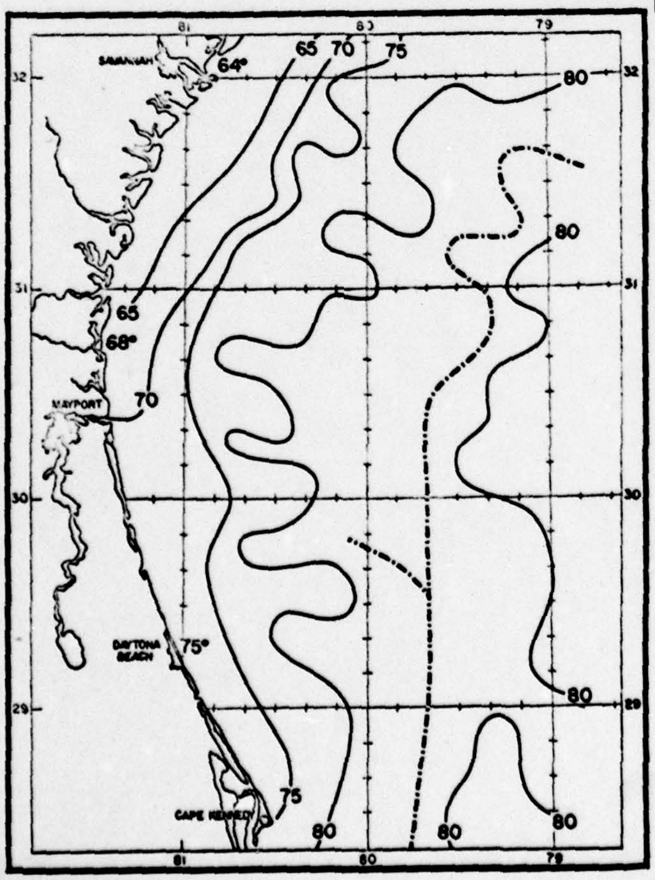
December

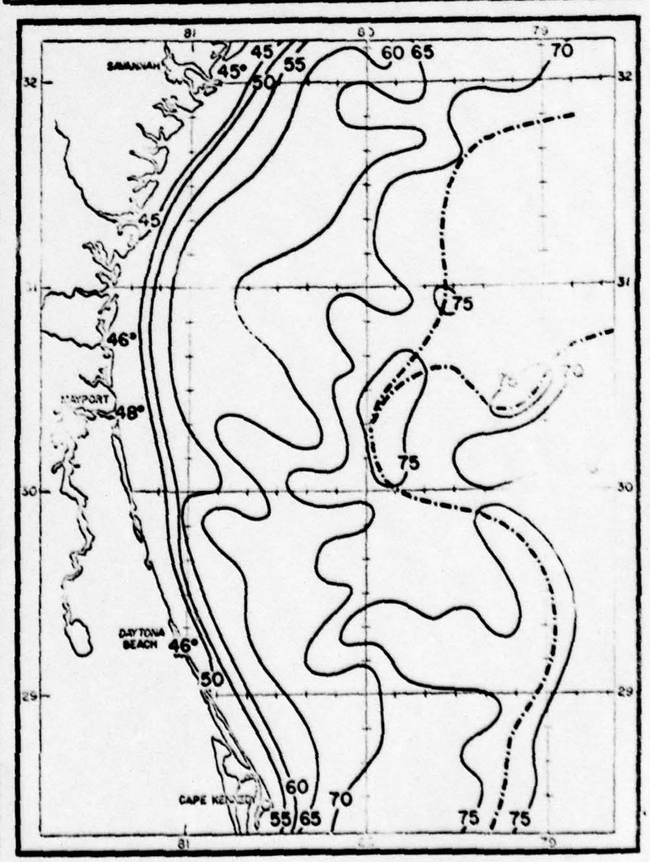
Right. Average SST
Normally, the isotherms will be plotted for each 5° F., however, if an intermediate isotherm is used, it will be dashed. Prominent warm cores in the Plateau Current will be marked by a dashed and dotted line.

Lower left. Maximum SST

Lower right. Minimum SST
The maximum charts essentially represent the extent that the Plateau Current meanders shoreward. The minimum SST charts represent the extent of the Plateau Current meanders off-shore. The off-shore meanders usually result in an apparent break in the main current with a resurgence of the steep gradient forming along the continental slope.





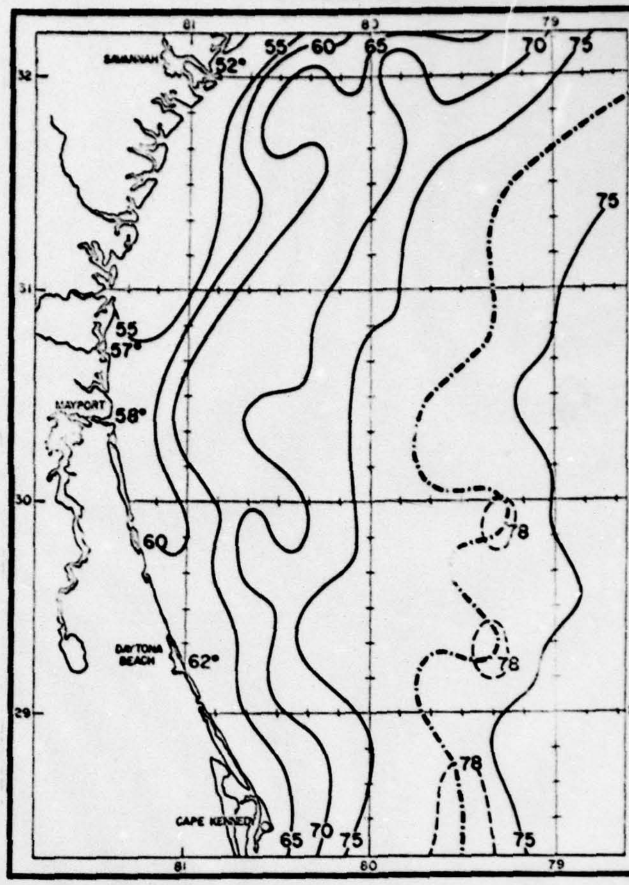


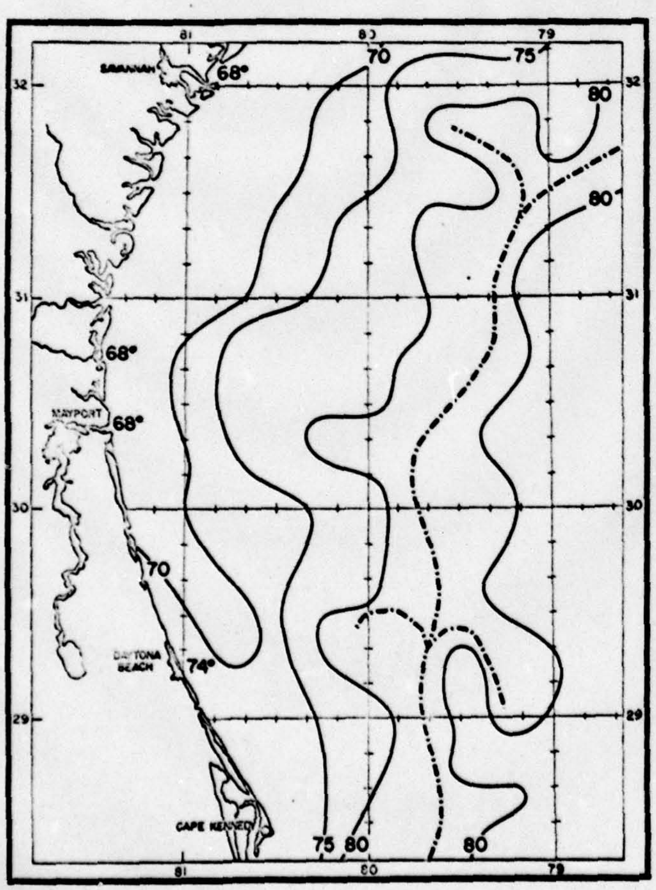
January

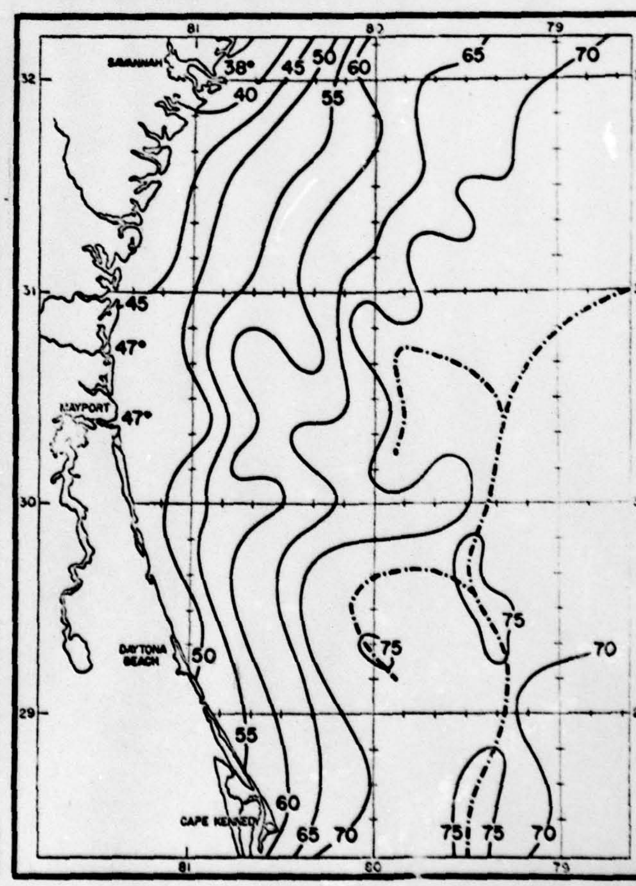
Right. Average SST
This is the coldest month for the average SST at Savannah (Ft. Pulaski), Georgia; Fernandina Beach, Florida, and Mayport, Florida. The warm core was so distinctive during January that intermediate temperatures (dashes), and the warm core (dashes and dots) were both marked. There is the possibility that these warm spots (about 30-40 miles apart) represent the tops to an internal standing wave in the current.

Lower left. Maximum SST

Lower right. Minimum SST





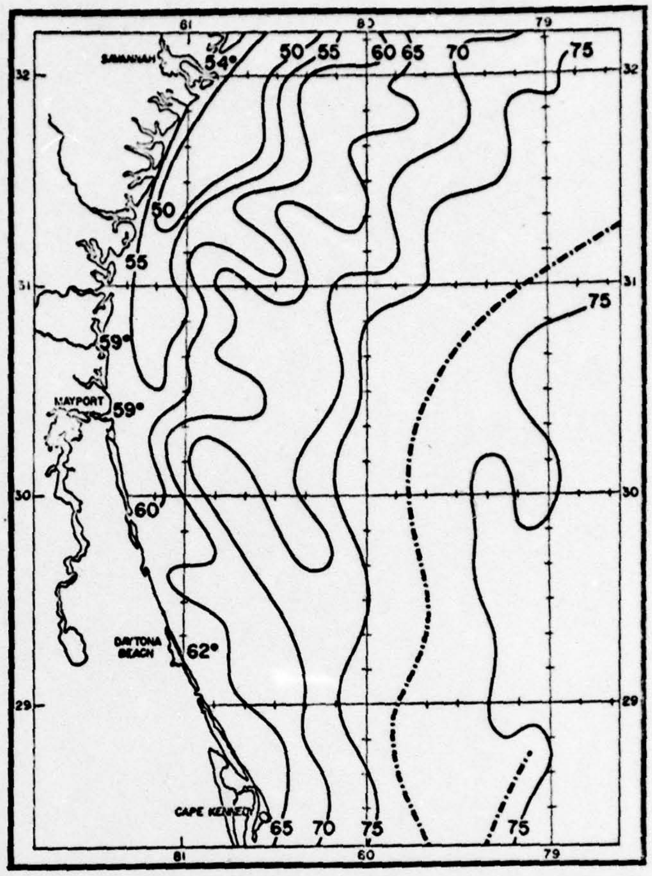


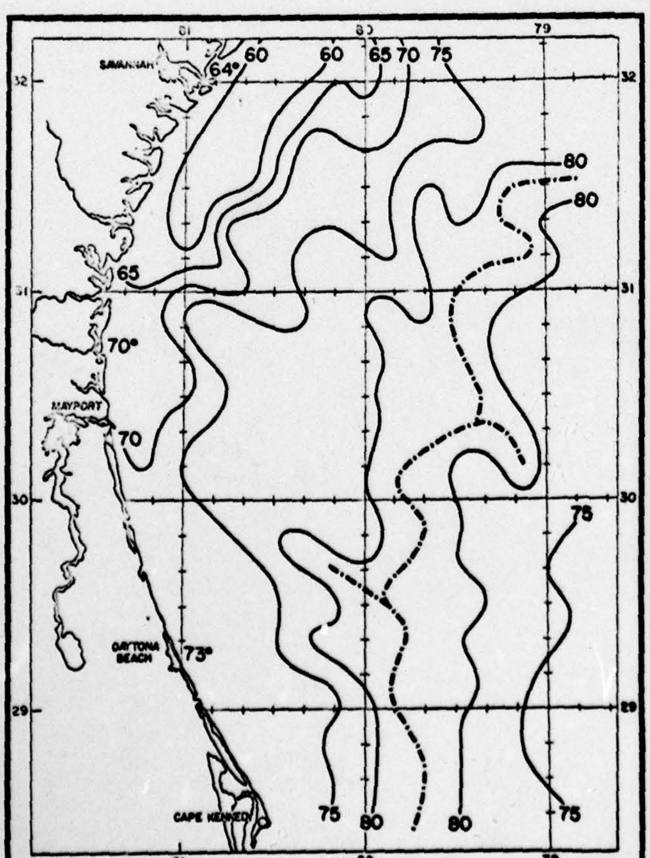
February

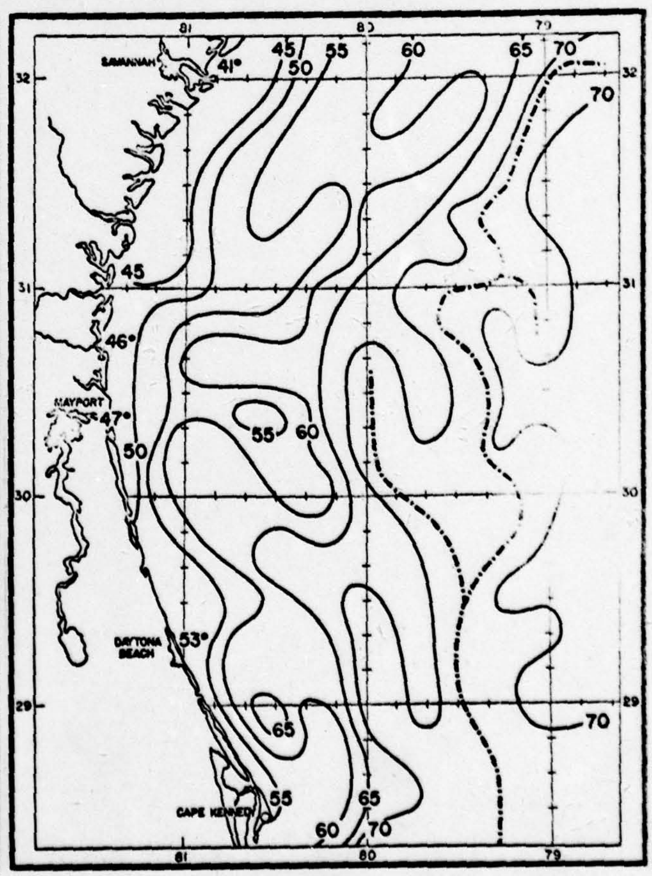
Right. Average SST
The Shelf Current is noticably colder than the Littoral Current during February. The Plateau Current makes its swing to the northeast at a slightly lower latitude than it does during the other months of the year.

Lower left. Maximum SST
The separation of the Shelf Current from the coast is also apparent on this chart.

Lower right. Minimum SST
The surface exchange of cold and warm water reaches it peak on this chart.





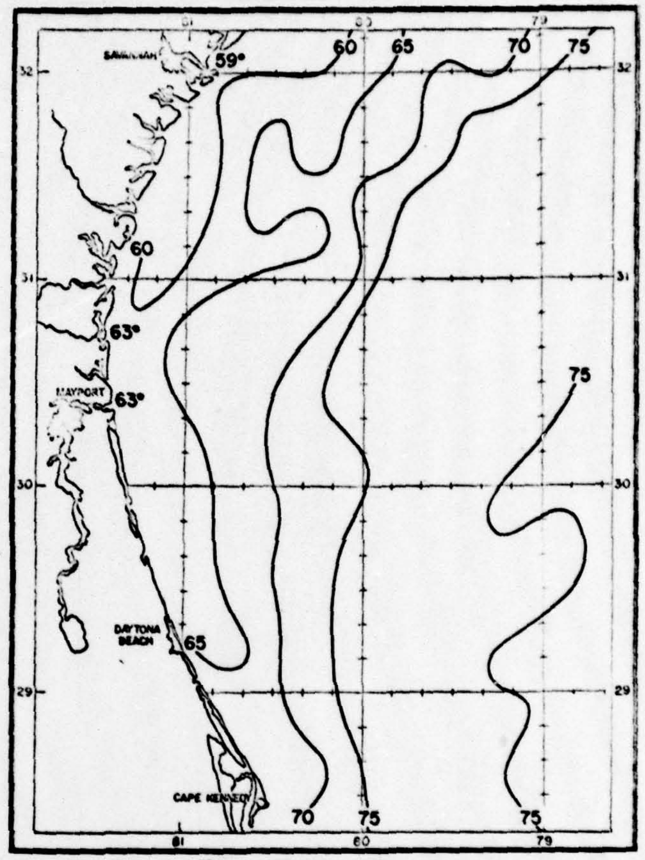


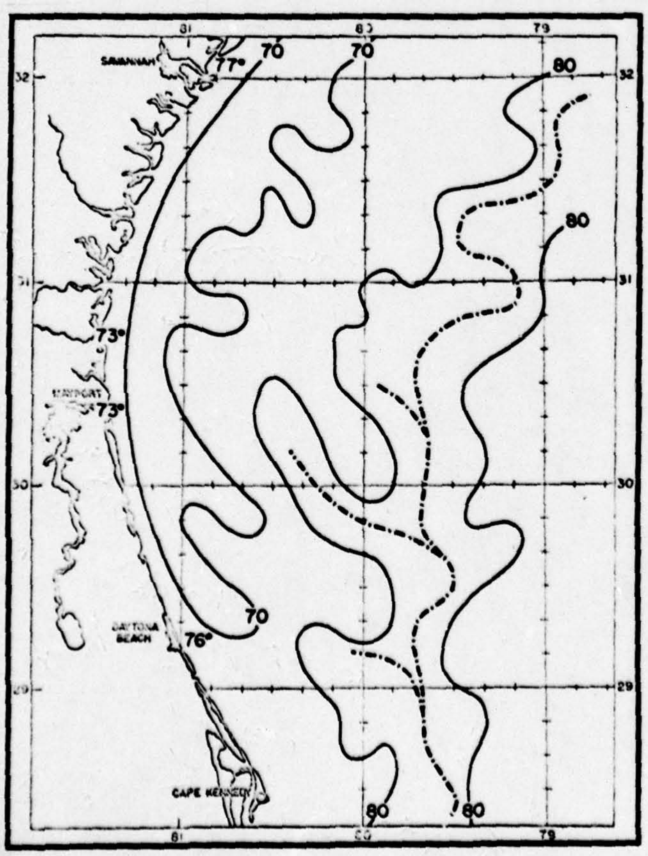
March

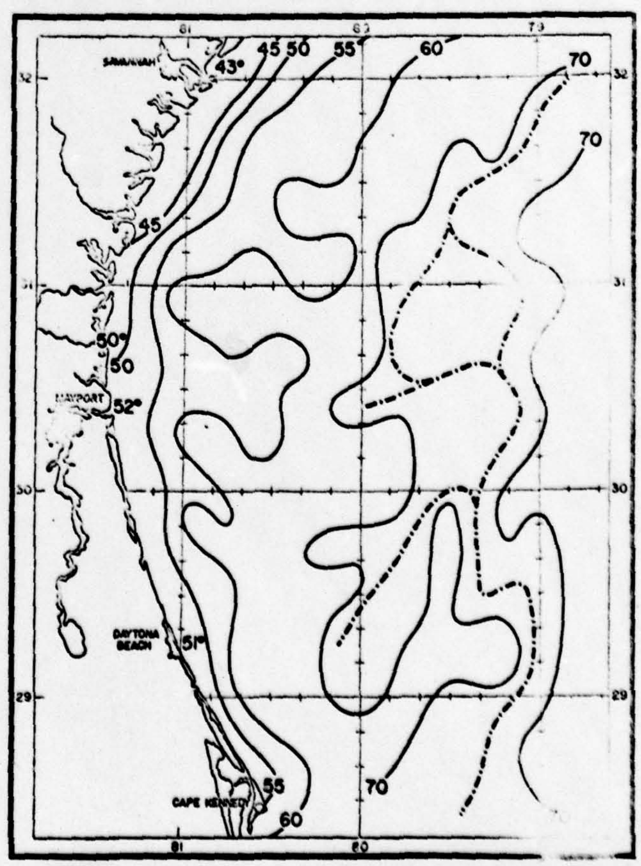
Right. Average SST
Vernal warming of the surface is masking many of the current features.

Lower left. Maximum SST
The cold Shelf Current is separated from the coast over its entire length in this study area. 75° F. isotherm was deleted.

Lower right. Minimum SST
Note the unusually large intrusion of cold water that starts near Cape Kennedy and extends into the Plateau Current for over 90 miles. For a cold current to extend over the warm water of the Plateau Current this far without sinking the cold water would have to be very fresh. This period coincides with the increased Spring rains. 65° F. isotherm was deleted.





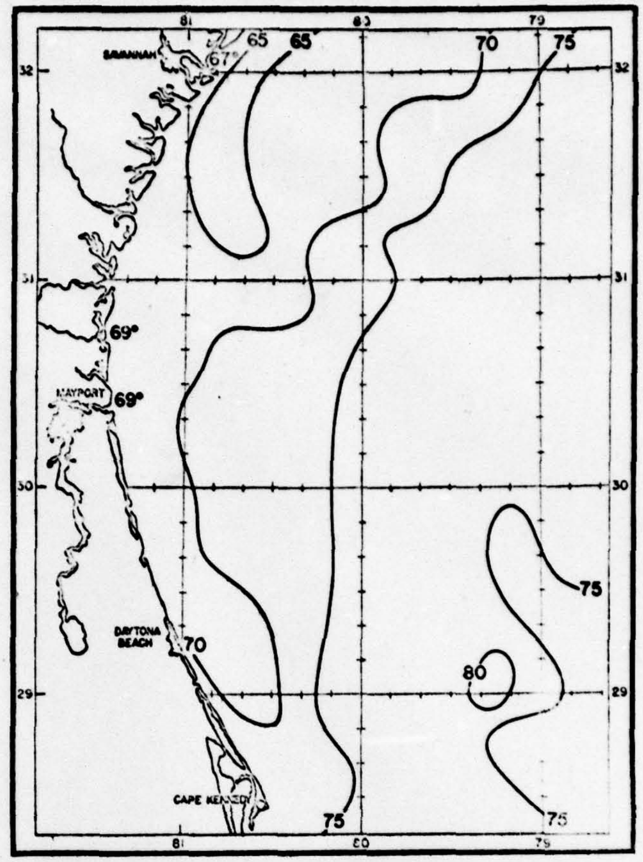


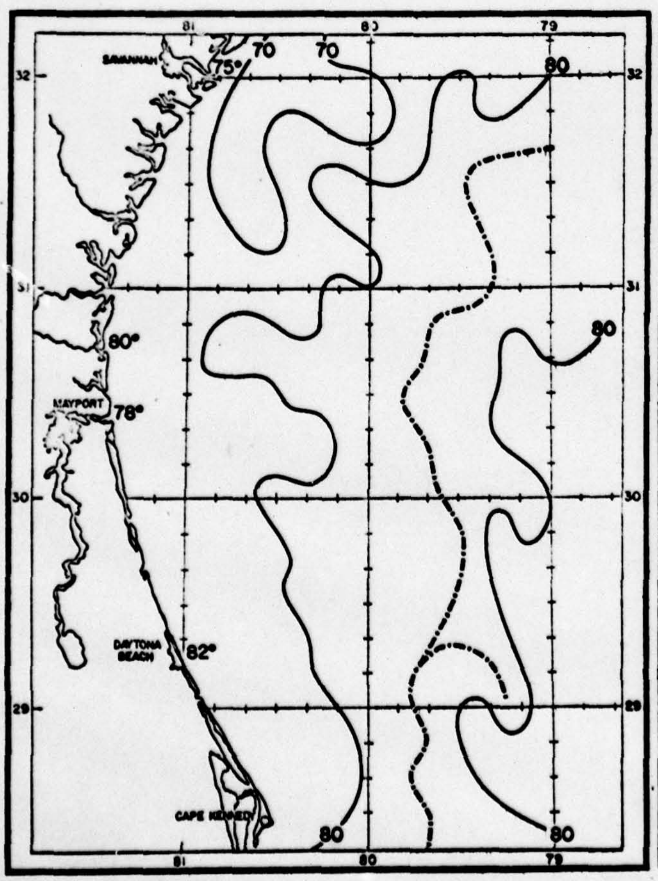
April

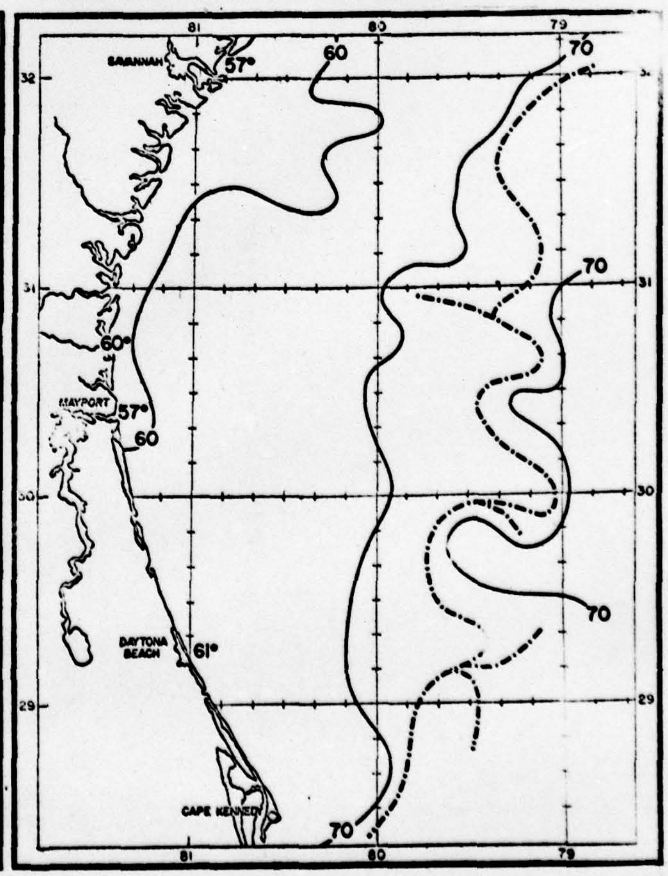
Right. Average SST

Lower left. Maximum SST
75° F. isotherm was deleted.

Lower right. Minimum SST
65° F. isotherm was deleted.





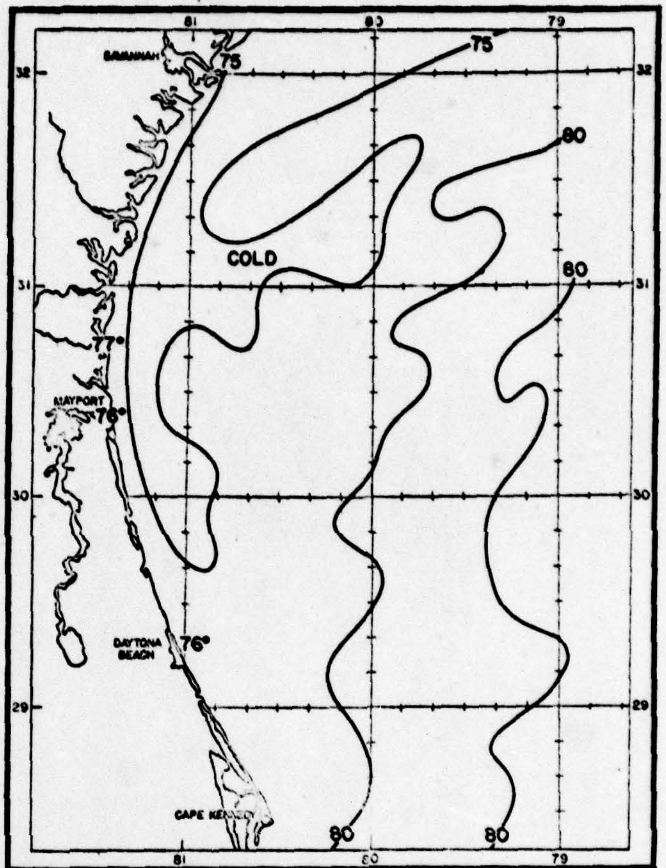


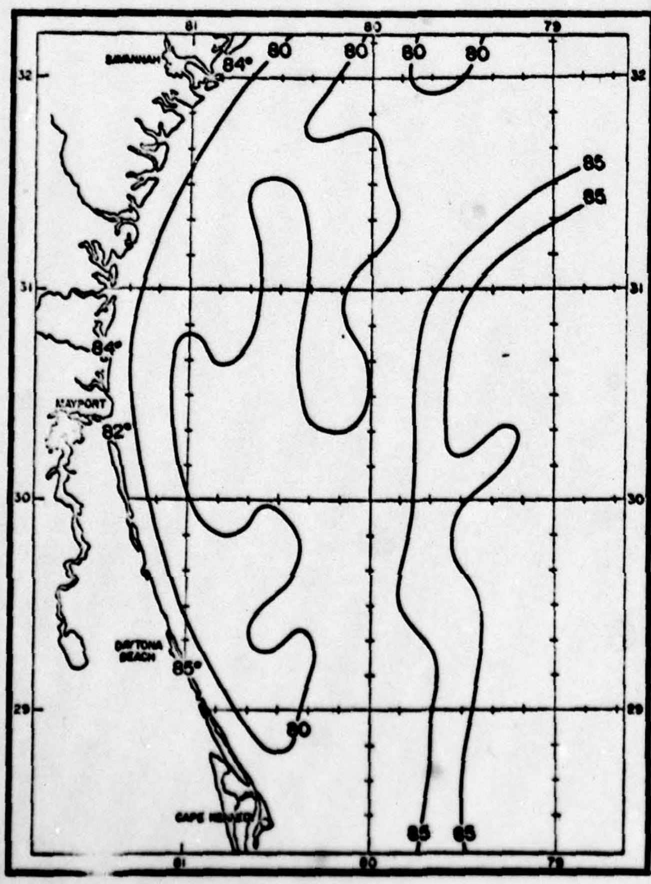
May

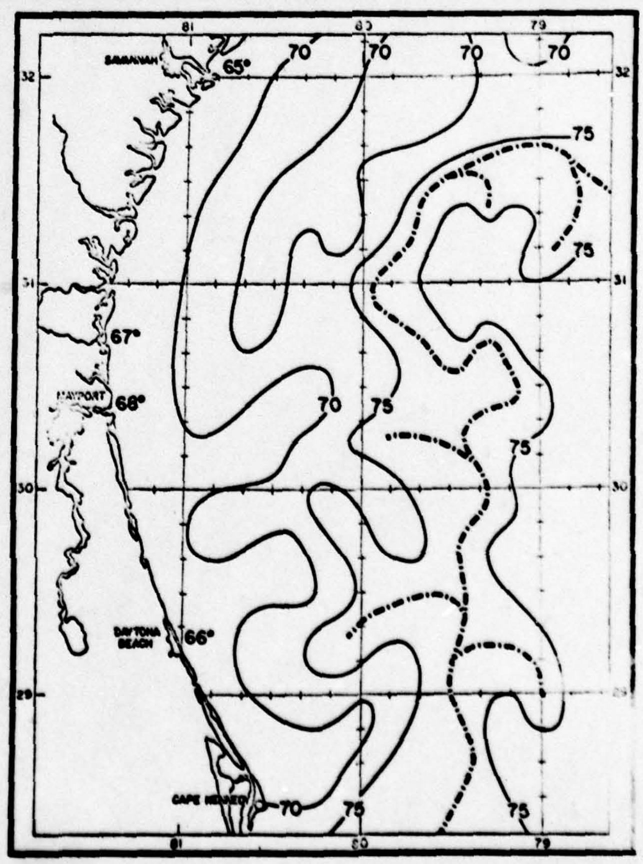
Right. Average SST

Lower left. Maximum SST
The cooler Shelf Current is still separated from the coast by a warmer Littoral Current.

Lower right. Minimum SST





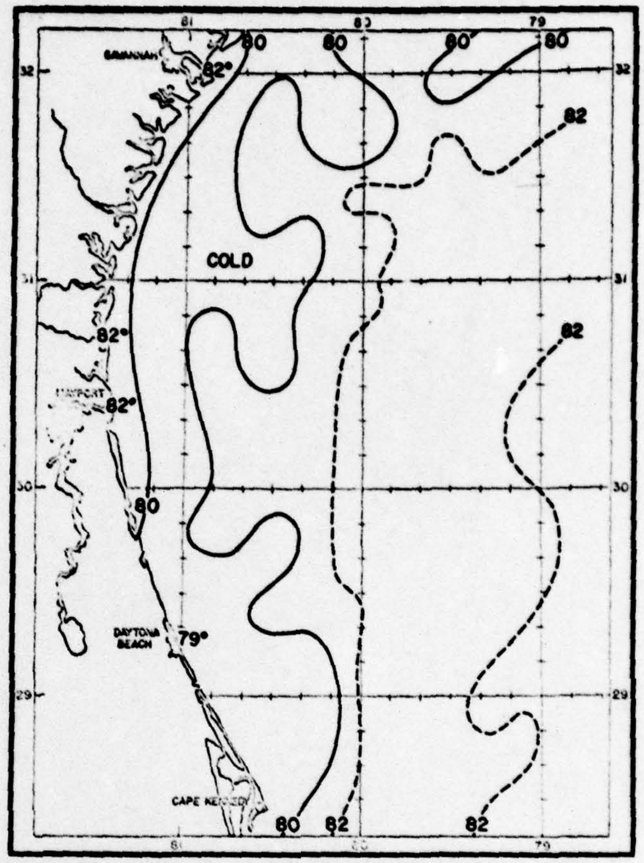


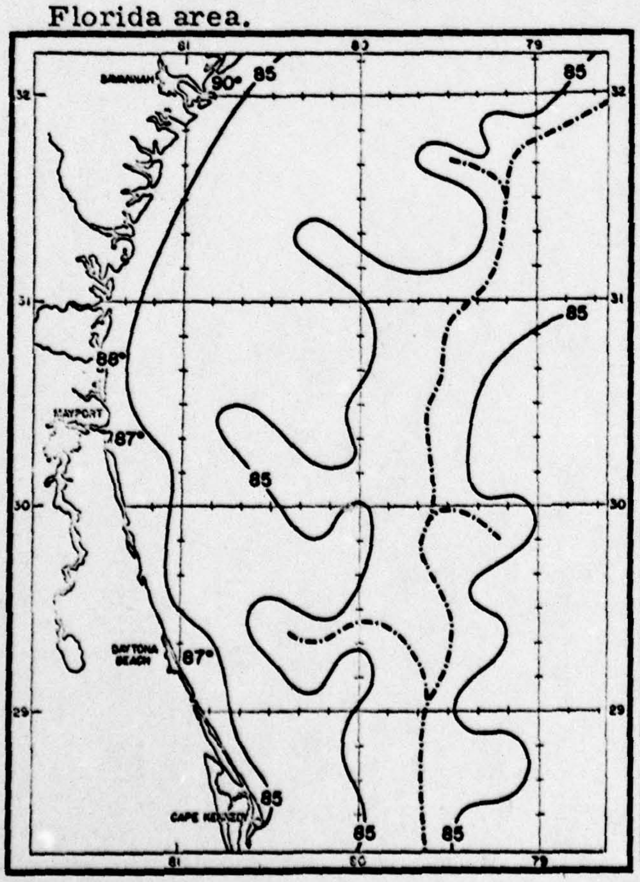
June

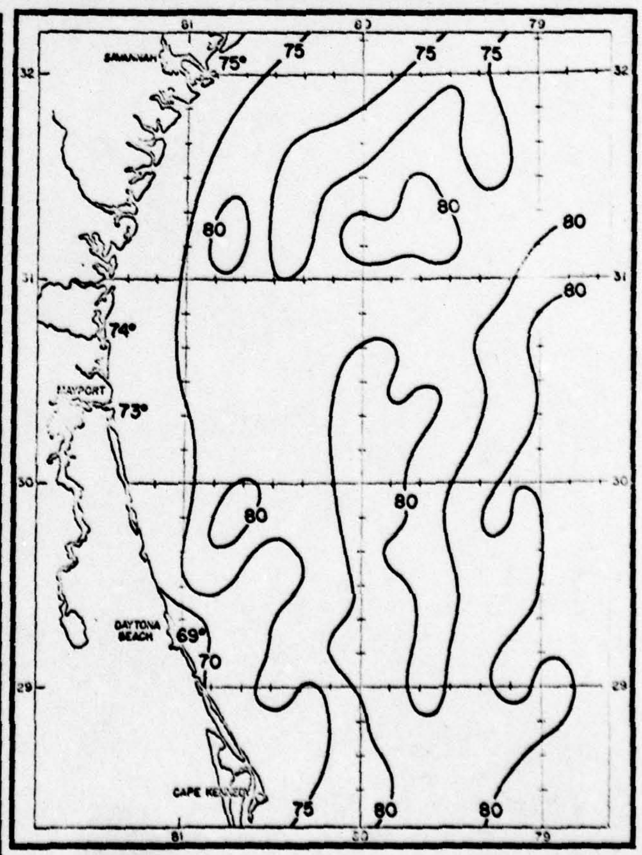
Right. Average SST
The cooler Shelf Current is in contact with the coast north of Savannah, Georgia and south of St. Augustine, Florida. The warmer Littoral Current in-between these two points is influenced by the warmer river run-off, as mentioned earlier.

Lower left. Maximum SST
The warmer river run-off has influenced the Littoral Current over its length north of Cape Kennedy. The slightly cooler Shelf Current apparently extends south of Cape Kennedy.

Lower right. Minimum SST
The Plateau Current is ragged with a cooler water intrusion extending southward between the two branches almost to Cape Kennedy. Note the cooler section in the Daytona Beach, Florida area.





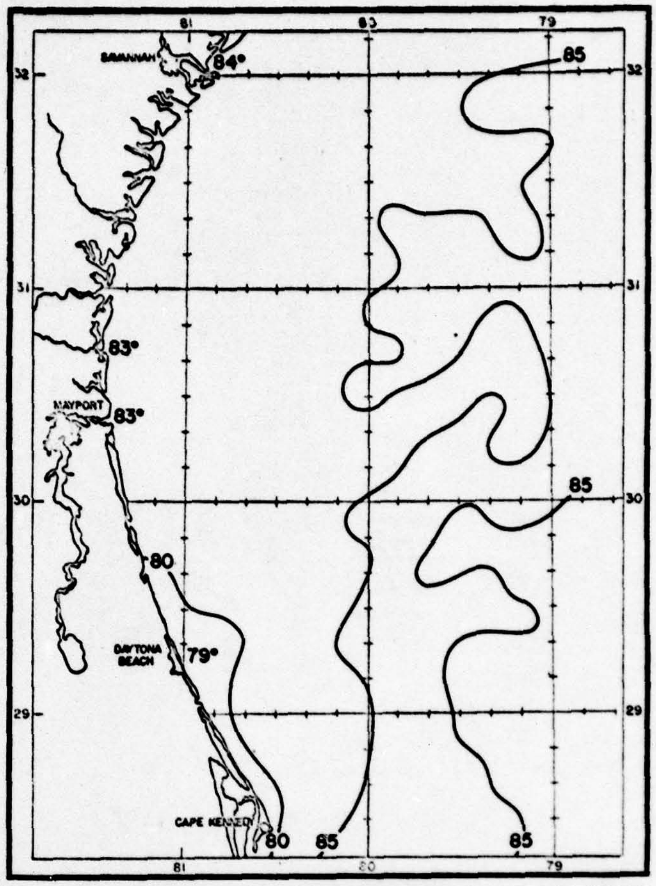


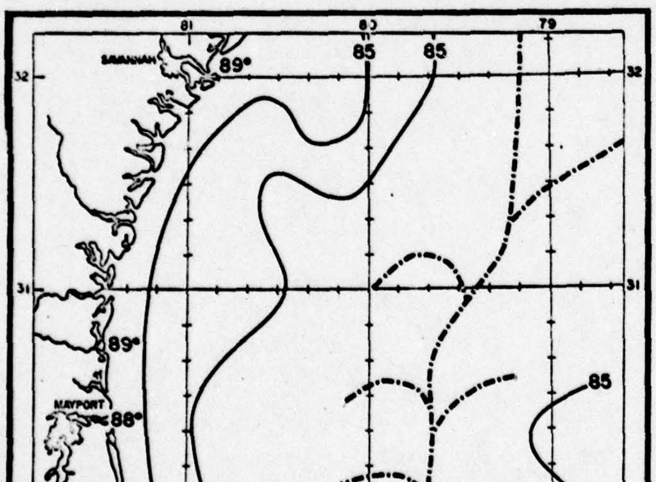
July

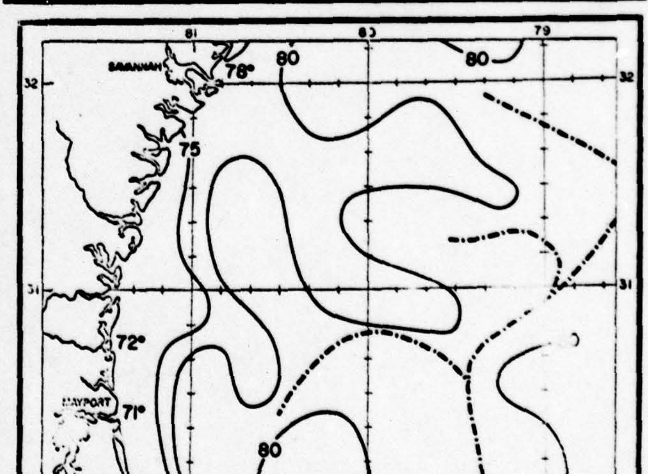
Right. Average SST
Surface warming has almost leveled the gradient so that water only slightly fresher than the Plateau Current can float over it. Taylor and Stewart (1959) have suggested that the cool area in the vicinity of Daytona Beach, Florida is caused by upwelling based on tide station data. This phenomena is noticable on the average and minimum charts, when the Plateau Current has meandered farthest from shore.

Lower left. Maximum SST
The Shelf Current is completely offshore with the warmest part of the Littoral Current to the northwest, which is to be expected with the river temperatures higher than the ocean.

Lower right. Minimum SST





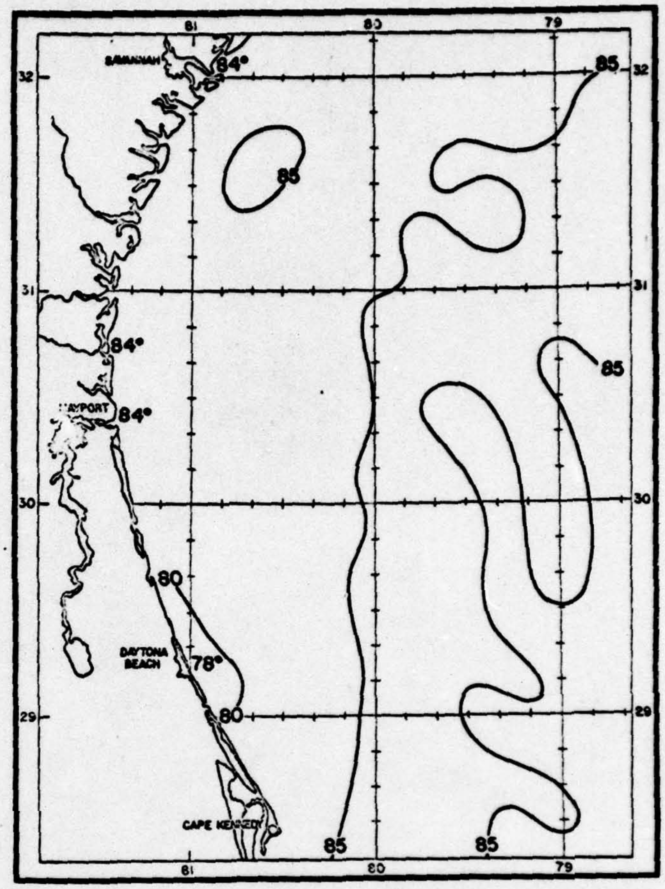


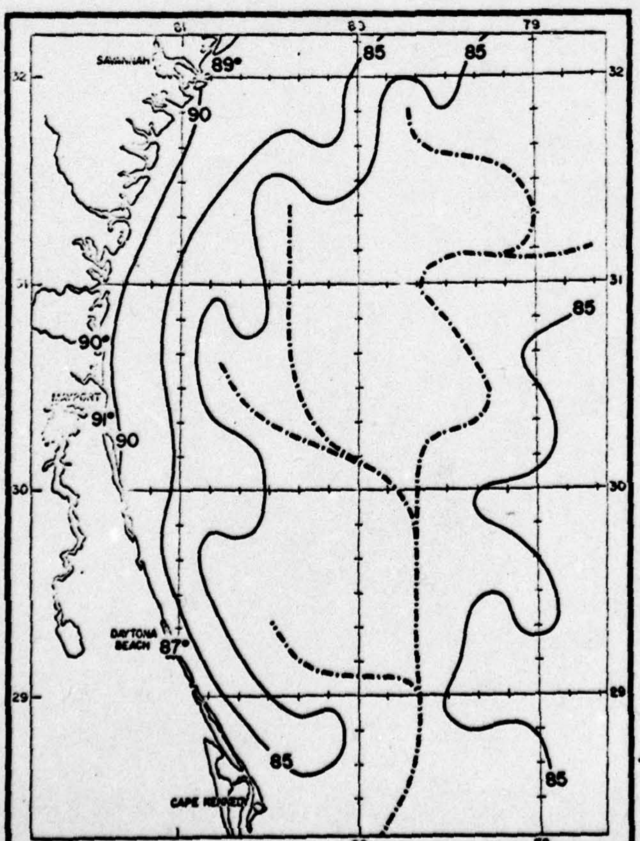
August

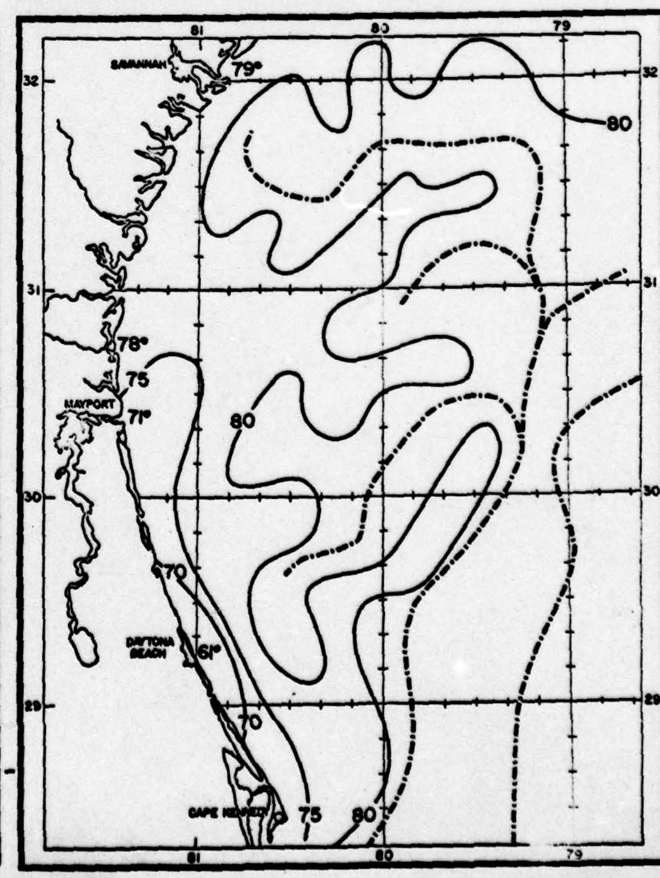
Right. Average SST

Lower left. Maximum SST
The cooler Shelf Current is slightly further off-shore during August and is not discernable south of Cape Kennedy.

Lower right. Minimum SST
There are many extensive intrusions of cooler water into the area of the Plateau Current, but no apparent Shelf Current. The coolest water at the surface is in the Littoral Current area from Mayport, Florida south. The Plateau current has no apparent eastern boundary and two distinct warm cores. One of these warm cores meanders within 10 miles of the coast southeast of Savannah, Georgia.





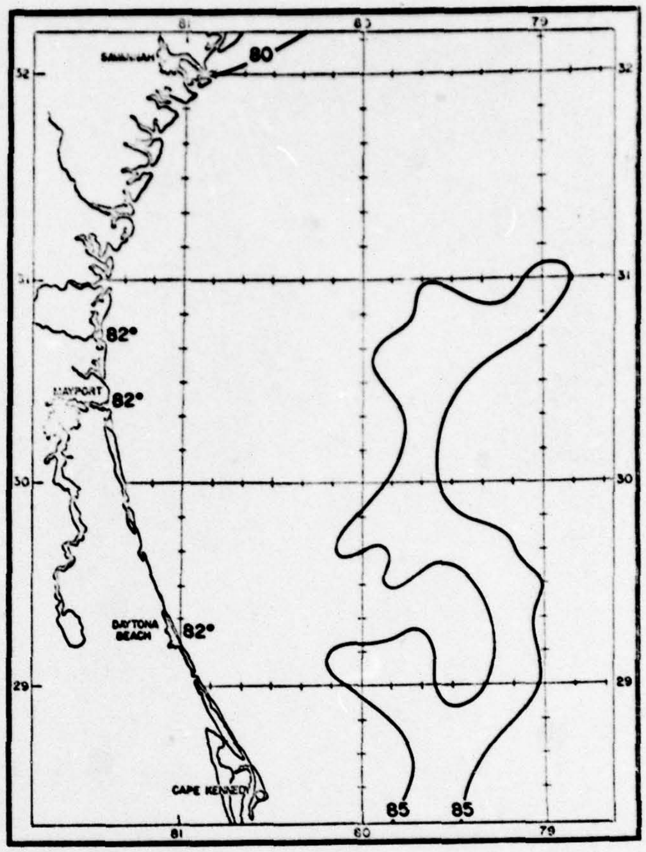


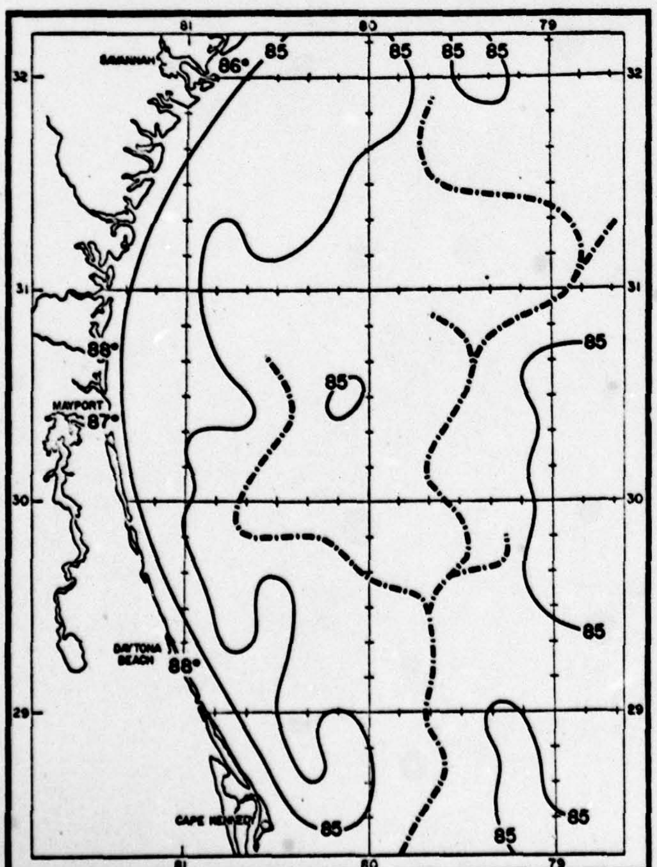
September

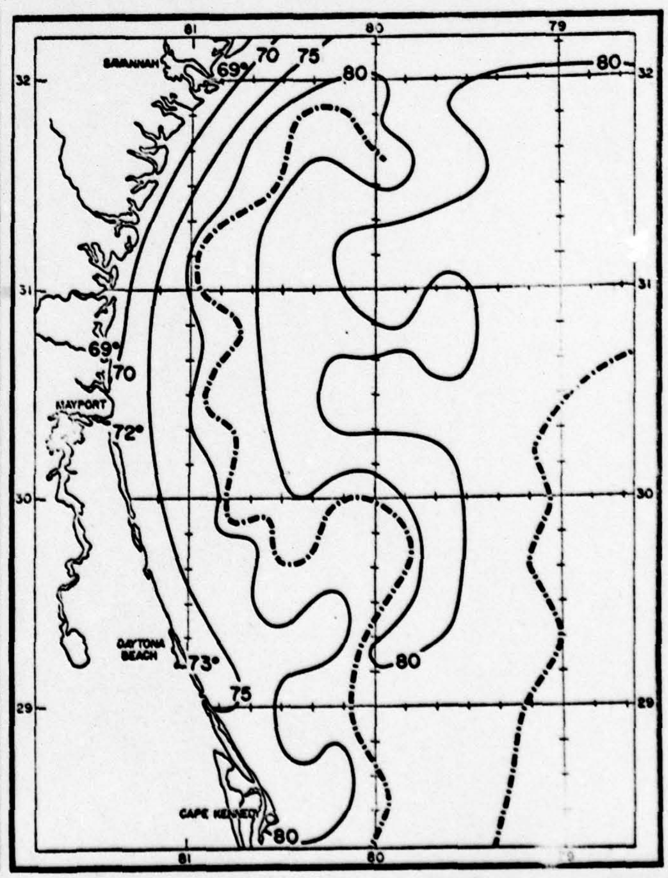
Right. Average SST

Lower left. Maximum SST
The cooler Shelf Current has moved closer to the coast with evidence of increased strength in the Cape Kennedy area. Cooler water from the Antilles Current, on the east, has decreased the width of the Plateau Current to about 40 miles.

Lower right. Minimum SST
The cold Littoral Current has reformed. Once again there is no apparent eastern boundary to the Plateau Current and the surface current has two warm cores, one extending well inshore where the cooler Shelf Current would be expected. Possibly the cool section between the warm cores of the Plateau Current is the Shelf Current.



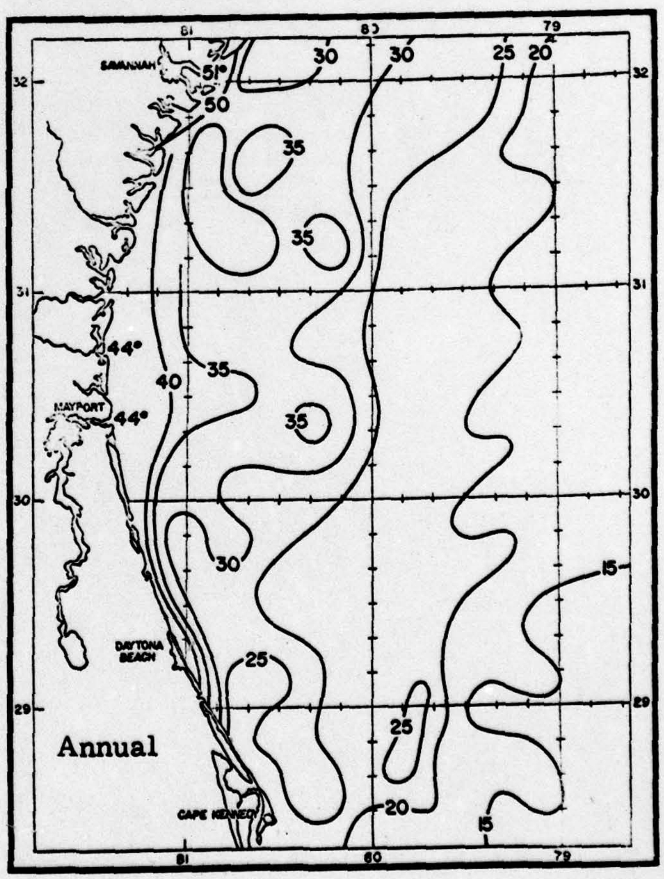


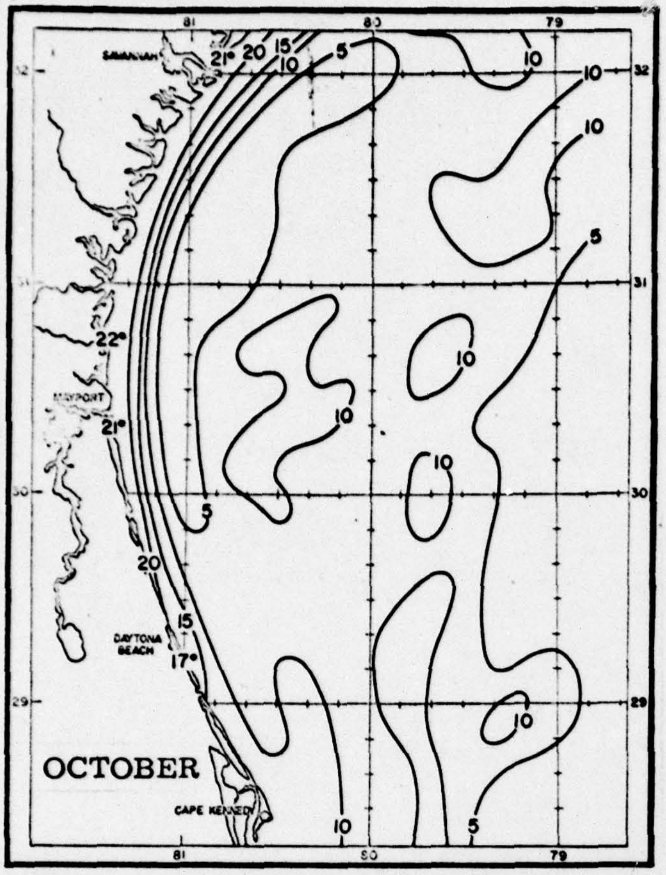


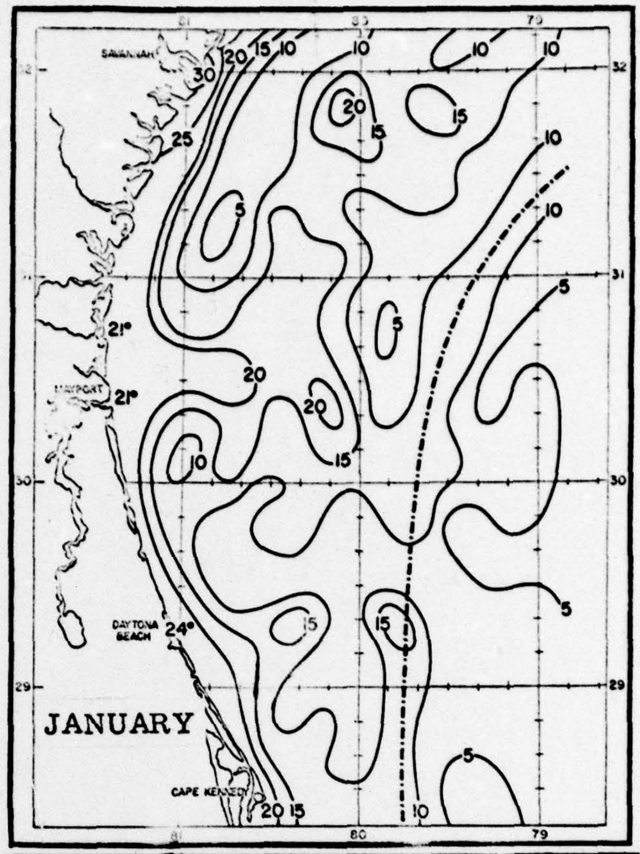
3.6 Sea Surface Temperature Range Charts (Quarterly and Annually)

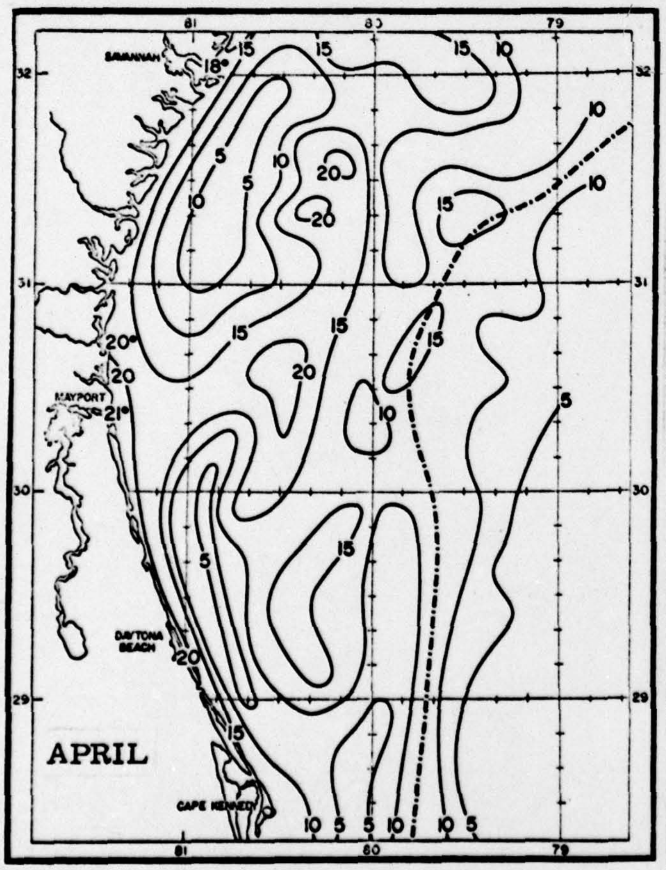
This series of charts shows the difference between the maximum and minimum temperatures for each data grid. The data was analyzed for each 5° F. of temperature range. They show at a glance which areas have the greatest range and probably the greatest turbulence. The annual range shows the degree of "continentality" to the data. The sea surface temperature annual range in the Savannah, Georgia area exhibits extreme continental influences (51° F.), while the range in the southeast section of the chart shows extreme tropical oceanic influences (15° F.).

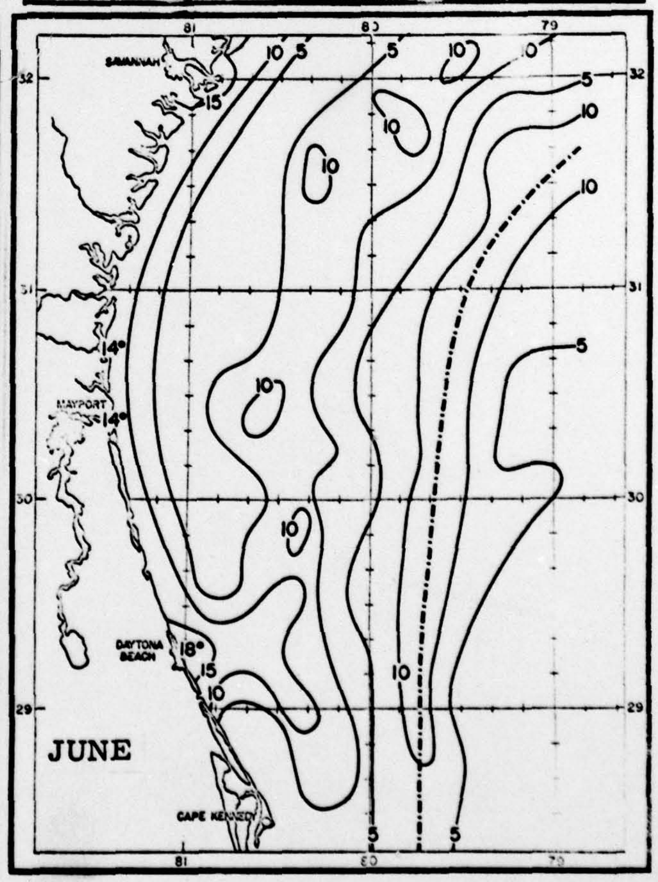
The theoretical center of the Plateau Current is marked with a dash-dot line. October is used as the starting month, because it is the month of the lowest current, as mentioned previously. June is used as the summer quarter month because the surface heating during July masks the features. The high range section at Daytona Beach, Florida is also at the southern point of its cycle during June. It is farthest north during February.




OCTOBER
SAVANNAH
MAYPORT
DAYTONA BEACH
CAPE KENNEDY
21°
22°
21°
17°
81
80
79
32
31
30
29


JANUARY
SAVANNAH
MAYPORT
DAYTONA BEACH
CAPE KENNEDY
21°
21°
24°
81
80
79
32
31
30
29


APRIL
SAVANNAH
MAYPORT
DAYTONA BEACH
CAPE KENNEDY
18°
20°
21°
81
80
79
32
31
30
29


JUNE
SAVANNAH
MAYPORT
DAYTONA BEACH
CAPE KENNEDY
14°
14°
18°
81
80
79
32
31
30
29

3.7 SST Case Studies

The ocean (or any large water mass) will act as a heat source or heat sink for the surrounding area, depending upon the relative temperature, wind, and stability. For areas adjacent to the water that have fog, low stratus, or thunderstorm problems, the sea surface temperature is a key factor in many forecasting rules. The analyses in this paper should prove that relying upon a single source for sea surface temperatures (i.e., a tide station, light ship, etc.) may not give a true picture of ocean conditions and very likely will not produce optimum forecasting results.

The following case studies are 3-day composites prepared from the data recorded by one, occasionally two, U. S. Navy aircraft carriers during their routine hourly weather observations. Normally the ship's position is recorded with the weather observation only at the 6-hourly synoptic times. This means that had the weather office aboard these ships recorded the ship's position with every weather observation there would have been 6-times as much SST data that could have been plotted. If the entire quantity of information available were usable (i.e., SST with positions), then there would be twice as much information per day as was available for each of the present 3-day composite case studies. Daily operational analyses similar to these case studies could be easily prepared if the data that is being currently observed by military and commercial vessels could be made available in usable form.

It has been noted from the case studies that the SST gradient steepens

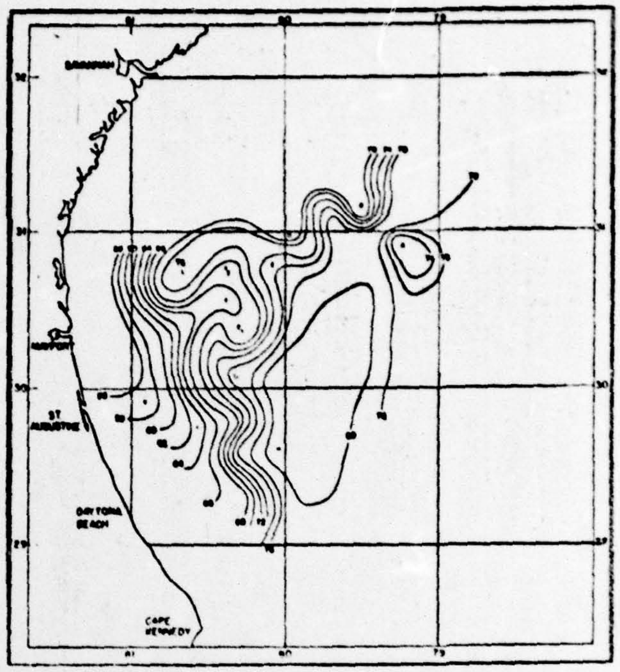
noticeably about every 6 to 8 days. When several SST features are moving in the same general direction the steep gradient area will track more to the right, or toward the center of the Plateau Current, and on occasion pass through the current to the eastern side. Major features occur at intervals, or wavelengths, of somewhere between 30 and 60 miles. Features having a wavelength of greater than 60 miles usually split into smaller units; those with less than 30 miles merge to form larger units. It is not unusual to have various features of the current structure apparently moving in unrelated directions and speeds.

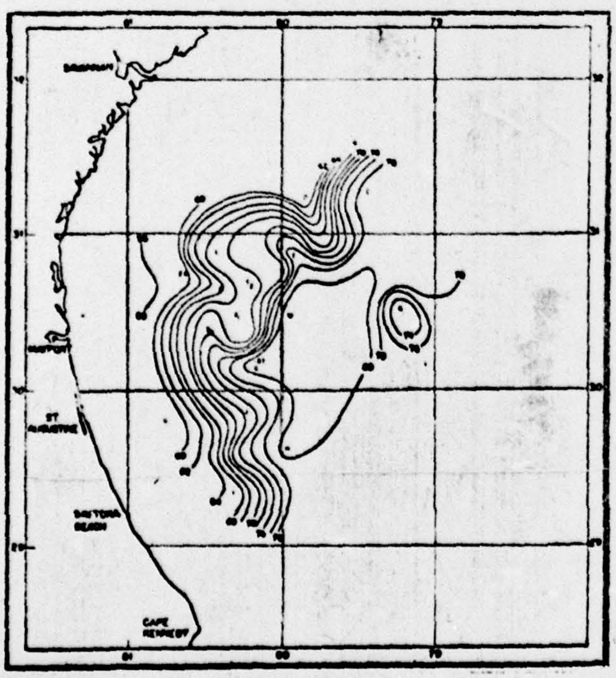
Many of the features on the following case studies have been labelled so the same feature can be followed from chart to chart. The shapes on the analyses resemble mesoscale atmospheric features in some respects, but the resemblence ceases at about that point. There are obviously many more things happening in this area than has been commented upon. Further study of more detailed data should prove valuable to the air-sea interface, heat budget, and ASWEPS fields as well as to synoptic and long-range weather forecasting.

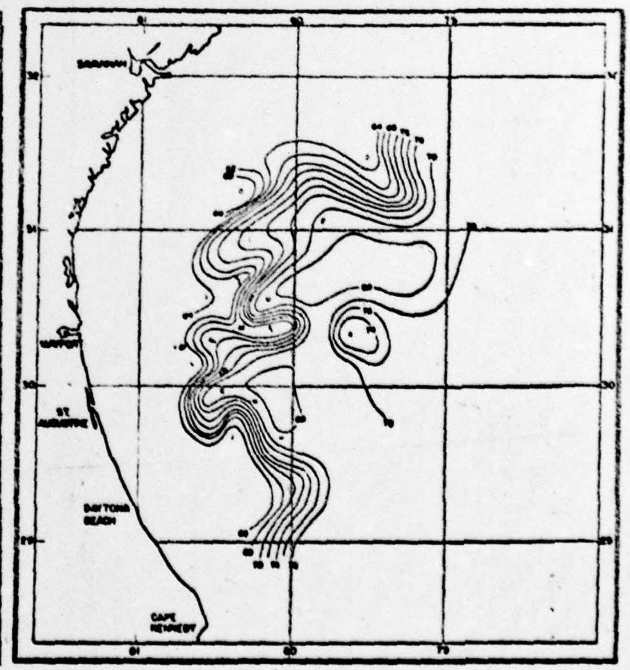
January 10-12, 13-15, 16-18, 1962

The cool eddy A on the January 10-12 chart has crossed the Plateau Current from B. In the subsequent charts it tracks south and appears ready to rejoin the Plateau Current from the east on chart 16-18. During the first period this cool eddy moved about 9 miles a day to the south, but in the last period it moved less than 2 miles per day as it curved to the west.

As pointed out in the average SST chart section, the Plateau Current is far from a river of warm water flowing smoothly through a cooler ocean.



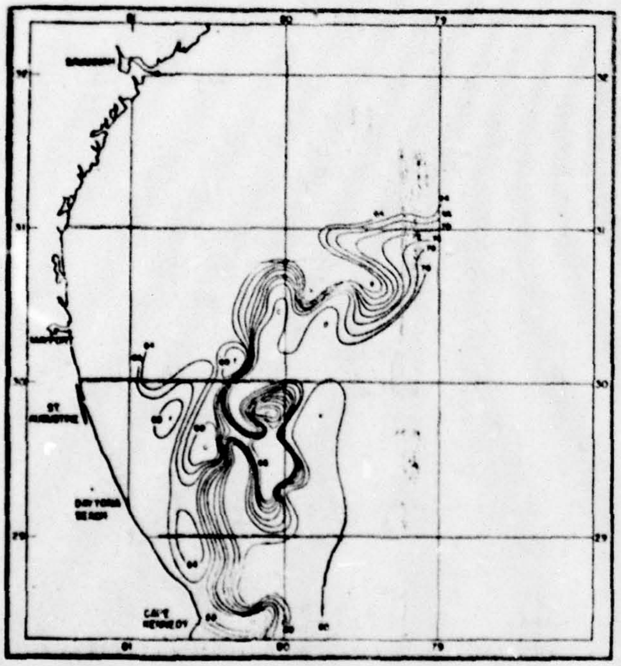


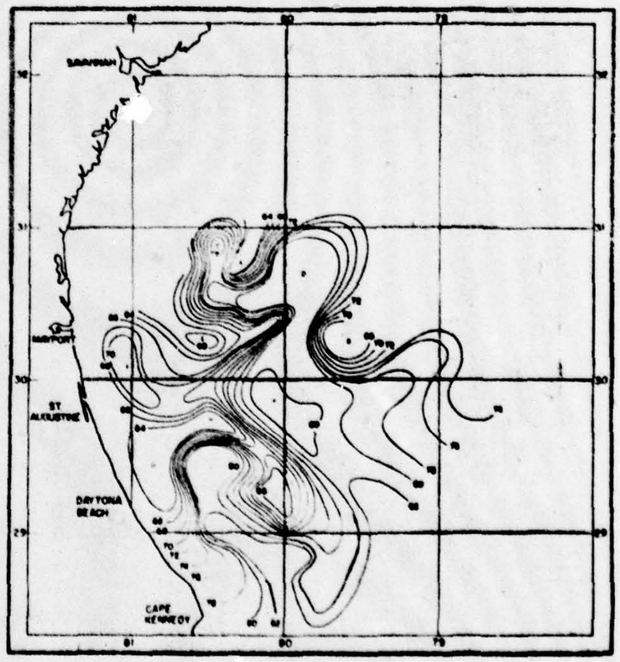


March 19-21, 24-26, 1964

There is a 3-day interval between the charts on this two chart series. Among the many things that are apparently happening are cold surges at A, B, I, and E; and warm surges at C, D, and J. It is hard to say whether B broke through the Plateau Current, or the Plateau Current meandered westward and cut it off.

A light northeast wind during March 19-21 could cause sea fog at Cape Kennedy if other conditions were favorable. The later chart shows the cooler water off-shore in the St. Augustine - Daytona Beach area. The in-shore meander at J is nearly complete on the second chart (see maximum SST for March), L will probably expand and move south, G would then also move south and bring the fog-favorable conditions back to Cape Kennedy by the 28-29th.

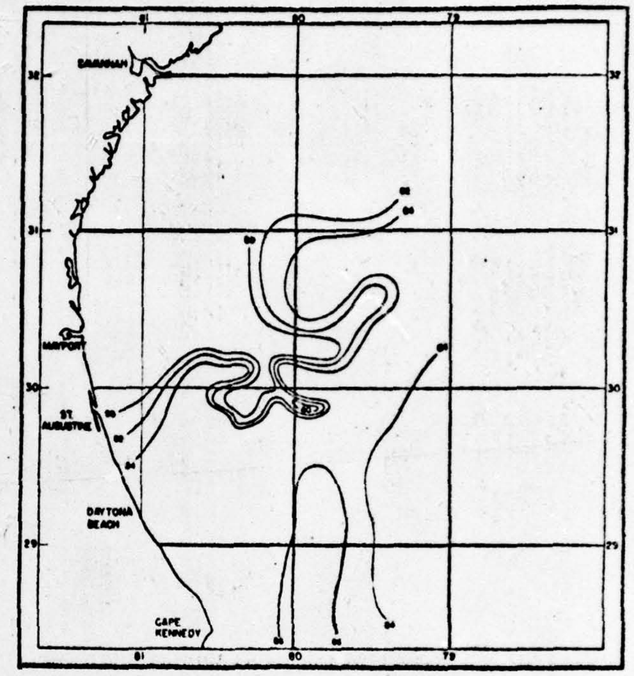




August 20-22, 1961

As might be expected from the other SST analyses for August the case studies also lack complex patterns. Most of the features are masked by surface warming.

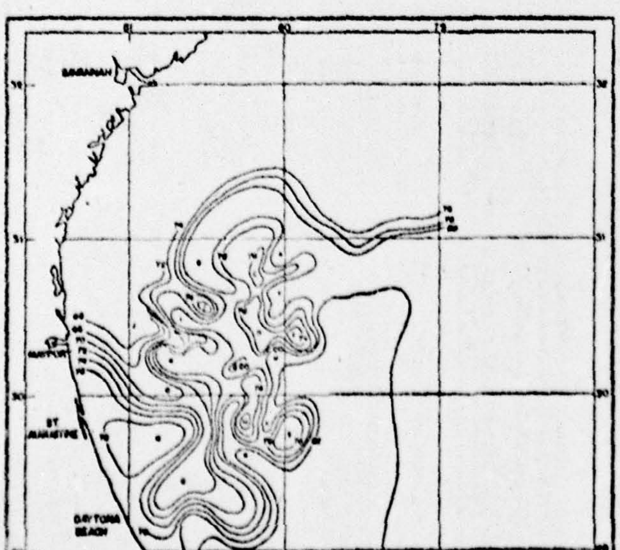
A flat gradient area of 80° F. SST occupies the northwest area from the coast to about 80° W. Some turbulent activity breaks through the surface layers to form a line of eddies where this cooler water meets the Plateau Current. The water to the east of the Plateau Current is consistently a degree cooler on this chart.

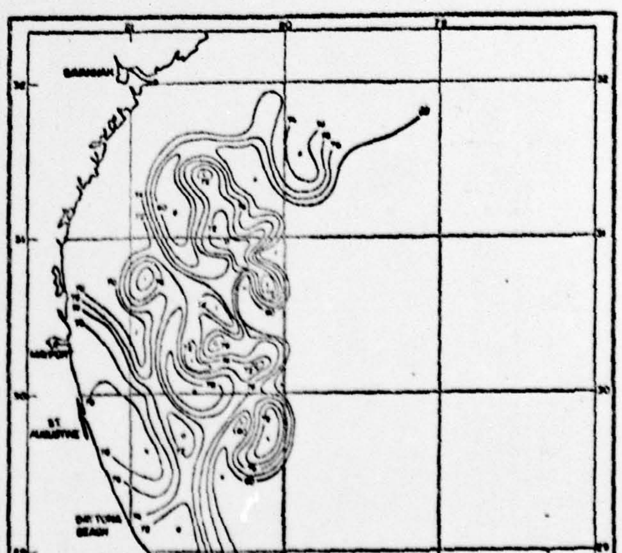


December 9-12, 13-15, 1961

In the analyses of the bathythermograph data (not included) along the continental slope, cold water surges (or internal waves) which extended from near the surface to below 700 feet (possibly to the bottom), have occurred several times. At present, there is not enough data to determine the period or the amplitude, if these occurrences are periodic. In this chart series there are several areas which have apparent upwelling. The wind was variable and decreasing during this period, so any upwelling would have to be caused by some force other than the wind. This upwelling could be the result of turbulence caused by these internal cold water surges or waves, with some of the cold water reaching the surface. This apparent upwelling occurs at C, D, E, M, and S.

The 82° F. isotherm has meandered eastward and could not be traced accurately so it was dropped from the later chart. The letter X designates a new cold water surge from the north on the second chart. Occasionally, and for no obvious reason, a mass of water will remain stationary and the rest of the area of eddies will track around it. This is what has occurred at N, which seems to be a favored place for these current oddities.





4. SUMMARY AND CONCLUSIONS

4.1 Iselin (1933) divided the Gulf Stream system into three major parts to alleviate the confusion about which section of this current system should be called the Florida Current, the Gulf Stream, and the North Atlantic Current. Definition of conditions and areas are vital to advancement in any science, however, there have been some objections to calling the current north of the Straits of Florida the Florida Current. Other definitions have been proposed, but calling the current between the Straits of Florida and Flemish Cap the Gulf Stream fails to take proper scientific notice that there is a difference between a current:

(1) that is bounded by the continental slope and one that is not,

(2) that is 800 meters deep and one that is over 4,000 meters deep,

(3) that extends to the bottom and one that has deep countercurrents,

(4) that is rapidly increasing in volume transport and one that is slowly decreasing in volume transport.

The current system should be divided at the points where there is a major change in characteristics. Therefore, it is proposed that the current from Tortugas to the northern mouth of the Straits of Florida be called the Florida Current; that the current from the northern mouth of the Straits of Florida to the point where the current leaves the continental slope, southeast of Cape Hatteras, be named the Plateau Current (as it does pass over the Blake Plateau); that the current from this point to a point south of Flemish Cap be called the Gulf Stream; and that the remainder of the current

east of the Flemish Cap be called the North Atlantic Current, as it has been previously.

4.2 Oceanographic atlases are customarily compiled for data grids of from 1 to 5 degrees of latitude and longitude. Pyle (1962) prepared an atlas based on a 30 minute (1/2 degree) grid which greatly improved the presentation of the finer features of the current systems. However, when the data was expanded to this study area, the detail disappeared. By using all available data and plotting on a 12-minute (1/5 degree) grid, a rather complex Littoral and Shelf Current appears in addition to the Plateau Current. The data density is not sufficient to prepare a land station type SMAR (Summary of Monthly Aerological Reports) for any one grid square, but by matching the data with data from adjoining grids squares, individual observational discrepancies are usually apparent. This allows analyses in quite fine detail and with reasonable accuracy.

4.3 From these analyses air-sea interface studies can be brought to a scale that would be more meaningful in the local area. Pilot investigations into the effect these variations in sea surface temperatures have on cloudiness, fog, haze, rain, and thunderstorms have proven most enlightening. Data and findings in this area will be presented at a future date.

4.4 It has been proposed by Rossby (1936) and others that the Shelf Current is an elongated vortex, between the coast and the Plateau Current, but not extending as far north as Cape Hatteras. Miller (1952) found that drif bottles released north of Cape Hatteras rarely rounded the Cape (only tw

were ever recorded as having beached south of Cape Hatteras). The analyses of the sea surface temperature structure implies that there is a south-flowing littoral current along the coast and that eddies, in general, follow a counterclockwise pattern and revolve about this elongated vortex. This action, combined with the meanders of the Plateau Current, makes movements of the meanders or eddies unpredictable on all but a very short time scale.

4.5 The analyses of this data implies that a steep SST gradient is associated with a strong current, but that the lack of a steep SST gradient does not necessarily mean that there is a lack of current.

4.6 The case history data is based on observations made routinely by one, or at most two, U. S. Navy ships using the Jacksonville Fleet Operating area. Analyses of this data shows that SST charts can be made of mesoscale SST features in an operational time scale.

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